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OBITUARY—EDWARD J. KING.

Again are we called upon to chronicle the death of a deservedly prominent and heartily esteemed member of the fraternity—in the person of Mr. Edward J. King, President of the Western Gas Association, and Secretary, Treasurer and Superintendent of the Jacksonville (Ills.) Gas Light Company. Although deceased had been complaining since mid-September last, it was only a fortnight ago that his malady assumed a phase that brought serious anxiety to his friends—typhoid fever was the disease for which he was being treated—but from that on the development of unfavorable symptoms was so rapid that nature yielded him up at an early hour on the morning of October 28th. That this sad news will shock the fraternity, particularly of the central West, but feebly puts it, for deceased, apart from being the executive head of the Western Association, enjoyed and firmly held the esteem of an imposing personal following. With this brief preface, we place the following summary of his honorable career before our readers.

Deceased was born in Jacksonville, Illinois, on June 14, 1849, in what is now known as the old Bristow house—a veritable landmark of the city—and was the son of the late J. O. King, who passed away on April 16, 1887. His preliminary studies were brought to a close in the public schools of his native city, after which he took a scientific course in the Illinois College, supplementing the latter by a special polytechnic course in an Eastern college. Having completed his education he returned to Jacksonville, where he engaged in mercantile business, meeting with a good share of success, meanwhile devoting much of his attention to assisting his father in the management of the Jacksonville gas works, which had long been in the care of the senior King. Increasing years, together with the rapid growth of the business of the Company, eventually caused the younger King, at the solicitation of his father, to give up all other pursuits to devote himself entirely to the gas business. To be absolutely correct, however, it must be remarked that deceased did remain a member of the local insurance firm of Doan, King & Upham, retiring therefrom when King senior passed away.

Although we feel it to be unnecessary to comment, by way of explaining to the fraternity that the Jacksonville Gas Company was a well managed concern, on Mr. King's ability as an engineer, it nevertheless should be said that his practice was of the most advanced sort, and that he was ever ready to listen to what even seemed to promise progress. While that willingness might lead others into danger, it never was so with him; for although radical perhaps in his wish for advance, a well-balanced mind, brightened by contact with the mercantile world, and sharpened by the training of youth continued through manhood, enabled him to separate fact from fancy, and to reject that which was perilous. In proof of this we would cite an instance that occurs to us from one of the past meetings of the Western Association—the tin wedding, if we mistake not. The question-box at that meeting contained, among others, the following query: "What is the best way to fight the electric light?" To the surprise of many present Mr. King replied that the best way in his opinion was to operate gas and electric plants in conjunction. Of course, as an *exparte* opinion that verdict might not be worth much, but as the Jacksonville Company had then actually been engaged in the supply of electric light for two years (1885), it had the convincing force

of practice behind it. This incident is merely given to show that while others were debating the practicability or good policy of the dual supply, King had already solved it for himself; hence that he was progressive and positively so.

It is rational to suppose that such a man would be largely interested in the material prosperity of his native city, and a look through its records amply bears out such belief. He had a large interest in the Jacksonville Manufacturing Company; was a Director in the *Daily Journal* Company, and Secretary of the Business Men's Association. In his religious and social obligations and responsibilities we also find him where men are found. He was a vestryman of Trinity Church, a Trustee of its charitable fund, and ever ready to lend a helping material hand where honest poverty asked for aid. He was a prominent Mason, and was also affiliated with numerous other societies having the promotion of some good for their object.

As a member of the Western Association, however, was where his light attracted the attention of his fellow gas men. He was one of those who, at St. Louis, Mo., on September 19, 1878—his esteemed father, the late J. O. King, being in the Chair—organized the Western Gas Managers Association, and his fealty to its best interests has never wavered. When the roll-call was read Ed. King was always on hand to respond to his name, and his time and counsel were ever at the Association's command. Further than that, his pen furnished food for fruitful thought on more than one occasion, as the Association's paper lists bear witness to. In the first year of the Western's history Mr. King served on the Board of Directors, and then up to '82 we do not find him occupying any of the executive positions, although the records teem with his services on various committees. In 1882 he filled the Secretary's chair in the absence of Lee A. Hall, and how well he acquitted himself there is a matter of history. In 1887 he was chosen to the office of Second Vice-President, going to the First Vice-Presidency in '88, preparatory to his unanimous elevation, in 1889, to the office of President. Thus in a double sense is the Western bereaved, in that it loses a founder and its reigning President. Well do we remember with what acclaim his election to the chief office was received—but of what avail are these recollections. These memories are now in the first blush of our sorrow hardly fitted to fraternize with grief.

He was also a valued member of the American Gas Light Association, having been elected to membership therein on the occasion of the eighth annual meeting, held in Chicago, 1880. While not so prominent in the affairs of the American Association, he was nevertheless a frequent attendant at its conventions, and always warmly welcomed, thereat.

We will make no attempt at elaborating his record in connection with our common industry, for it is an open book to those who keep up in its history. Keen, discriminating, upright and able, his capacity as a gas manager had, although often severely tested, never been found wanting in scope. All that can be said is said when the simple statement is made that as the father was so was the son.

His domestic life was of a piece with his public record—unstained and blameless. He was united in marriage on June 19, 1873, to Miss Ida Sawyer, daughter of Dr. C. K. Sawyer, of Jacksonville. His widow and four children—a son and three daughters—survive him, who mourn in all sincerity the loss of a husband and father in the truest sense of these endearing terms.

The funeral services were conducted by the Rev. Mr. J. C. Fulton, of Boonville, Mo., at Trinity Church, Jacksonville, and despite the short notice—it was necessary to cause the interment without delay—that only could be given, the edifice was thronged with mourners who represented every condition of Jacksonville's citizenship. In conclusion we can but say, speaking for ourselves, as friend and fellow of deceased, that death has taken away from us in the person of Edward J. King a man whom it was a pleasure to know, and whose memory shall remain with us to the end.

In connection with this brief history, we herewith append the resolutions that were adopted by the Business Men's Association of Jacksonville at the death of their late associate and Secretary:

I.—In the removal by death of Edward J. King, the Business Men's Association of Jacksonville is made keenly sensible of the loss of an efficient officer; of an active and useful member; of a wise and faithful friend.

II.—The Association recognizes the value of the services of Mr. King, as Secretary from the time of its organization; a position for which he was eminently qualified by a wide business acquaintance, a thorough understanding of the wants of our city, and by prompt and decided action in the performance of every duty imposed upon him.

III.—This Association desires to express its appreciation of the late Mr. King as an honored and worthy representative, at home and abroad, of our leading business interests, as a liberal and public spirited citizen, as a genial companion and a Christian gentleman.

IV.—Mr. King was a man of well-rounded and well-balanced character; of broad intelligence; dignified and courteous in bearing, genial and social by nature and quick to respond to all demands looking to the welfare of our community or to the advancement of the good name and prosperity of our city. The loss of such a man is one that is shared by an entire community. The business men of Jacksonville desire to express their sense of a personal loss in the death of Mr. King and to extend to his bereaved family their warmest sympathy.

Resolved, That this paper be spread upon the minutes of this Association, and that the Secretary be instructed to send a copy to the family of Mr. King, and furnish one to the city press for publication.

DEATH OF FRANCIS M. ROOTS.

Still another gap in the ranks has been caused by the death, on October 25th, at his house in Connersville, Ind., of Mr. Francis M. Roots, whose inventions in certain mechanical lines have made his name world-famous—prominent among these inventions are the principles of the rotary exhausting and blower systems that bear his name. The following special press despatch, bearing date of October 25th, is all that we have at present respecting his decease:

"Francis M. Roots, a well known philanthropist, banker and inventor, died at his home in Connersville to day, after a long illness. He was taken seriously ill in London, England, about four weeks ago, but rallied after arriving in New York. When he reached home it was thought he would recover, but a serious relapse terminated all hope. Deceased was born in Oxford, O., on October 28, 1824, and was the son of a well-to-do farmer. He received his education in the Miami University, and moved to Connersville in 1845, to establish a large woolen mill business, which, in connection with his brother, he conducted until about 1859, when he disposed of his interest and entered upon his career as an inventor. In 1860 he perfected the invention of the rotary blower, which is now in use at the Capitol, Washington, D. C., and in every Western Union office of any size in the United States. It is also extensively manufactured in Europe, Mr. Roots having large business interests in England and on the Continent. He was also the inventor and manufacturer of Roots' gas exhauster—known to the gas industry of the world—and Roots' steam pump. He did not confine himself solely to the manufacture of his inventions, being President of the First National Bank of Connersville, of the Connersville Furniture Company, and in several other branches of business in Connersville and Cincinnati as well. He was a leading member of the First Presbyterian Church, and widely known for his charity, having given largely to the Western Female Seminary, at Oxford, of which institution he was a Trustee at the time of his death. He leaves a wife and three children—Daniel T. Roots and Mrs. Dwight Johnson, of Connersville, and Mrs. Edwin Schively, of Philadelphia."

THE ANNUAL MEETING OF THE SOUTH-WESTERN ASSOCIATION.

It is with great satisfaction that we are enabled to announce with authority that at a meeting of the Executive Board of the South-Western Gas Association, held at Dallas, Tex., on October 22d—President Wm. Enfield, of Dallas, Vice-President A. E. Judge, of Austin, and Secretary-Treasurer C. P. Russell, of Houston, being in attendance—it was decided that the date originally set for the next meeting of the Association (to be held in Dallas) be changed from March 19 and 20 to March 12 and 13, 1890. This action was taken so as to avoid a clash of dates with the Ohio Association, which will grant all members, as well as others who desire to attend both meetings, sufficient time to effect their purpose, and by means of one trip. Secretary Russell reports that the favorable manner in which matters are progressing encourages the hope that a large attendance will convene in Dallas next March, not only of members of the Association, but of others who are interested in any way in the management of gas works. It is proposed that a "Question-Box" shall constitute one of the features of the gathering, and Secretary Russell empowers us to invite the fraternity of the North and East to avail themselves of this opportunity of learning something of the gas industry as practiced in the great and growing southwest, and to afford the representatives of the latter section an opportunity of securing an expression of Northern and Eastern views upon the best methods of promoting the gas business.

(Continued from p. 572.)

Instruments for Measuring Radiant Heat.

By C. V. Boys, F.R.S.

Lecture III.

Of the instruments for detecting feeble effects of temperature, the best known are those depending on the electromotive force set up in a metallic circuit composed of different metals when there is a difference of temperature between the junctions of the metals.

The elementary metals may be arranged in a series, with bismuth at the beginning and antimony at the end, so that if a circuit is made of any two, an effective electromotive force will be found tending to send a current across the warmer junction from the lower to the higher metal in the series. The greater the difference of temperature, and the further the metals are apart in the series, the greater, in general, will be the effective electromotive force. When the temperature differences become large, it will be found that the electromotive force is not exactly proportional to the difference, and in some cases not at all proportional—so much so that if the hot junction is heated, or the cool junction cooled, beyond a certain point, instead of an increase there is actually found a decrease of electromotive force. Though these departures from proportionality can be completely represented by the thermo-electric diagram of Prof. Tait, there is no occasion to consider this at the present time, for with such very small differences of temperature as we have to deal with in thermopiles and similar apparatus, the electromotive force is, as far as experiment can show, exactly proportional to the temperature difference for any mean temperature, and the effect of such small changes of temperature as are met with in a laboratory from day to day, while very small, can, if necessary, be exactly allowed for. We may therefore with propriety use the old-fashioned expression, and say that the "thermo-electric power" of any pair of metals is so much, and that the further the metals are apart in the series, the greater is their thermo-electric power. Turning, then, to the tables given in the text-books, bismuth and antimony being at the two ends, have a greater thermo-electric power than any other pair of simple metals. Iron and copper, which are intermediate metals, form, at ordinary temperatures, a combination of which the thermo-electric power is about one seventh of that of bismuth and antimony.

It is impossible at present to give any reason why the several metals should have the thermo-electric properties that they are found to possess. In the case of some of the alloys the properties are the reverse of what might be expected. Thus, though bismuth is the most positive, and antimony the most negative of the metals, an alloy composed of thirty-two parts bismuth and one part antimony is more positive than bismuth itself; though antimony is the most negative of the metals, and bismuth the most positive, and tin is nearly neutral, an alloy of twelve parts bismuth and one of tin is more negative than antimony. The first of these alloys, and one almost the same as the second, are stated by Lord Rosse to be the alloys which, at that time, Messrs. Elliot Bros. used in their thermopiles.

I have, with the help of Mr. Burbidge, examined these two alloys, and find that at ordinary temperatures they have a thermo-electric power one-third greater than that given by bismuth and antimony. They have this further advantage, especially over antimony, that they are both easily fusible, and can be cast in thin leaves between smoked glass plates.

The electromotive force acting in a circuit composed of these alloys, when the temperature differences between the junctions is one degree centigrade, is about 1-sixty-thousandth of a volt. As this is an enormous electromotive force for a delicate galvanometer, an exceedingly small temperature difference can be detected.

To still further increase the electromotive force it is usual to make thermopiles with a very large number of pairs of bars having their alternate junctions near together. Heat thus falling upon one side of the pile will warm the alternate junctions, so that the electromotive force due to all the pairs will be added together. In the pile now on the table, made by Elliot, there are eighty pairs of bars, and these are packed into a space only two centimeters square. Each bar has a section of about 2×1 millimeter.

As an example of the sensibility of the thermopile, I may give the following results obtained with the ordinary standard apparatus, namely, the thermopile referred to above, and an Elliot reflecting galvanometer of low resistance made to be used with the pile. When the magnet was so adjusted that the needle had an oscillation of six seconds, the heat from a candle flame at a distance of five feet produced a deflection of 110 millimeters of the spot of light, on a scale one meter from the mirror, that is with the reflecting cone in position. Without the cone the deflection was 31 millimeters. The candle flame is perhaps not a very scientific or exact source of radiant heat, but it is very convenient, and serves well when the object is to compare one instrument with another. If an improvement in an instrument is of so slight a character that the small variations of heat radiated from the flame of a candle of any definite make are liable to mask its effect, then the improvement cannot be of much consequence to anybody; but if by any means an instrument can be made ten or a hundred times more delicate, then the greatest variations in the candle flame will be insufficient to materially affect this proportion, and so, for practically testing the value of an instrument, there is no occasion to set up a more constant source of radiation.

I have given the results obtained with the standard apparatus so as the more readily to trace the value of more modern development. The resistance of all the bars of the pile and of the wire of the galvanometer, though not very great, is one of the factors that determines the strength of the current. If by any means the resistance could be reduced, the current would be increased in the same proportion, that is if the temperature difference remained the same.

Professor Forbes has devised a simple instrument, which he calls a thermo-galvanometer, in which the resistance is reduced enormously. He reasoned as follows: Imagine one pile of 20 pairs, and a second having the same outside dimensions, but consisting of one pair; then for any temperature difference, if the electromotive force and resistance of the pair are each called unity, the electromotive force of the pile would be 20, and its resistance 400. Now, since the resistance of the galvanometer most suitable for any pile is equal to that of the pile, the total resistance of the pile and galvanometer should be 800. If now the two ends of the pair are united, and not connected to a galvanometer at all, the currents in the two cases should be, by Ohm's law, $\frac{20}{800} = \frac{1}{40}$ in the case of the pile and galvanometer, and $\frac{1}{1} = 1$ in the case of the pair; so that with a simple pair the current should be 40 times as strong as with a pile of 20 pairs and a galvanometer. On the other hand, since there are many turns of wire in the galvanometer, the current may go round the needle so many times as to more than compensate for its feebleness; and though the simple pair so formed as to inclose a needle may not be more sensitive than the usual pile and galvanometer, yet on account of its great simplicity and cheapness it may be of value in some cases.

The form which Professor Forbes gave to his pair is shown in Fig. 9,

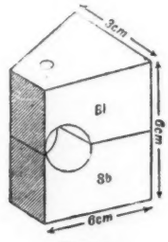


Fig. 9.

from which it will be seen that the sectional area of the metal is very great in all parts except at the face which is to be exposed to radiation. This face is filed away until the linear junction so formed is so thin that with further filing there would be risk of destruction. The face is then blackened so as to make it absorb heat freely. A hole drilled through the upper block allows the needle and mirror, which hang within the cylindrical hole in the block, to be supported by a thread from above.

Messrs. Nalder Bros. have kindly lent me one of these instruments of their make, which Mr. Burbidge and I have examined. Whether this is a good sample of the instrument I do not know, but in sensibility the instrument is far behind the thermopile and galvanometer. That it does not come up in sensibility to the value that the consideration of Ohm's law alone would lead one to suppose is due to the following causes. In the first place, whatever is done to reduce the electrical resistance of the bars applies also to their thermal resistance, and so, since this also is reduced to the greatest extent possible, the heat which falls on the hot junction can escape freely, and so the hot junction is not made so hot by the absorption of heat at a given rate as it would be if the thermal resistance were greater. Again, when an electrical current passes in a thermo-electric circuit heat is carried from one junction to the other by the current, and the quantity of heat which is so carried is proportional to the current strength. Since the current density in Prof. Forbes' in-

strument is at least twice as great as in the usual arrangement, heat is electrically carried from the hot to the cold junction at at least twice the rate for a given temperature difference; and so, if this were the only cause of equalization of temperature, the hot junction would be heated to less than half the extent above the cold that it would be if the current density were at the usual rate. However, I do not think this electrical transfer of heat is important in comparison with that due to ordinary thermal conductivity.

The only point in which my experience does not confirm that of Prof. Forbes is in the dead beat character of the instrument. He states that on account of the small resistance of the block of metal in which the needle is suspended, the electrical currents induced by its motion are sufficient to make it dead beat. The instrument that we examined showed by no means a large decrement; in fact, the great number of oscillations of the needle were a serious inconvenience.

Now, returning to the ordinary pattern of thermopile and galvanometer, the question is worth asking whether it is capable of improvement. Are the number of bars that the instrument maker happens to have employed the best number? Are the number of windings and the thickness of the wire in the galvanometer the best for the purpose? At first let the space filled with the thermo-electric metal in the pile, and the space round the needles in the galvanometer filled with wire be supposed constant, then there are two problems each of which has the same answer. They are, given a thermopile find the best galvanometer, and given the galvanometer, find the best thermopile. Let nothing be altered except the number of pairs in the pile, or of turns in the galvanometer, then all other kinds of variation, due to conduction of heat, radiation, etc., or to the magnetism or movements of the needle for the time do not exist.

If the pile is made with twice as many bars, its electromotive force will be doubled, but its resistance will be increased in a fourfold ratio. The increase of resistance is objectionable, while the increase of electromotive force is the reverse. There must be some number of bars which will be most advantageous. This is the case when the resistance of the pile is equal to the resistance of the galvanometer and connecting wires. The solution of the converse problem is the same, the number of turns and size of wire should be so chosen that the resistance of the galvanometer should be equal to the resistance of thermopile and connecting wires. These results are not quite true, because of the electrical transfer of heat, known as the Peltier effect already referred to. On this account the galvanometer resistance should be slightly higher than the resistance of the thermopile, but the heat transfer due to this cause is, as already mentioned, small in comparison with that due to thermal conduction.

The solution found at present is only relative. Given a galvanometer the best pile may be found, or given a pile the best galvanometer may be found; but we do not yet know whether both should have many bars and turns of wire, or a few bars and turns. Judging by the practice of instrument makers, who crowd eighty pairs of bars into so small a space, a great number would appear to be best.

Now, imagine a thermopile and galvanometer exactly suited to one another, and a second pair of the same pattern in every respect, except that they have just half as many bars and half as many turns of wire, each filling, of course, the same space. Then the total resistance in the second case will be one-quarter the resistance in the first, while the electromotive force will be one-half; the current, therefore, will be twice as strong, but as it goes round the needle only half as many times it will produce exactly the same effect.

This is a really true comparison, for the Peltier effect, heat conduction, radiation, etc., are the same in both cases, it therefore follows that since half the number of bars and turns is equally good, the same will be true of half the number again, and so on, until there is either only one pair of bars in the pile, or only one turn of wire in the galvanometer. It would, therefore, appear that all the trouble and expense of making so many pairs of bars in a thermopile is a waste, and that one pair is just as good as a million. This result is only true so long as the resistance of the connecting wires is sufficiently small to be neglected. If, as is sometimes necessary, the thermopile is some distance from the galvanometer, and if also flexible wires are essential, then, owing to the resistance of the connecting wires, many bars should be used, for just as they are increased in number does the resistance of the connecting wire interfere less and less. There is another reason of greater practical importance why many bars are advantageous, and that is that as the working electromotive force of the pile is increased, so, in proportion, do accidental electromotive forces produce less disturbing effects. For instance, at every binding screw there is a thermo-electric junction, at which accidental temperature changes, due to hot or cold draughts, handling, etc., set up electromotive forces which may be exceedingly troublesome. Or, again, if the connecting wires are any of them apt to swing about, each one in cutting through the earth's magnetic field will cause an electromotive force to be set up which may largely disturb the galvanometer needle.

It is only in the cases where these disturbing causes are met with that any advantage is gained by the use of a large number of bars. If they can by any means be avoided, then a single pair of bars does just as well as a large number.

The next thing to consider is whether the single pair, which is as good as a pile of eighty pairs if the galvanometer and connections are properly arranged, and which is at present supposed to occupy the space of eighty pairs of bars of the usual size, can be made more effective by increasing or decreasing its sectional area, its length remaining the same. Let it be reduced until it is half the thickness and half the breadth, then its resistance will be four times as great as it was, and the galvanometer, altered so as to have four times the resistance also, will have twice the number of turns. If it is possible to concentrate all the heat which would have fallen on the larger surface, also upon the smaller, then, since practically all the heat which falls on the hot junction is carried away by conduction, by radiation from the face, and by the Peltier action of the current, which each now go on at one-quarter the rate for any given difference of temperature, the hot end will acquire four times the excess of temperature; the current, therefore, will be the same, but it goes round the needle of the galvanometer twice as often, and so the deflection will be doubled. In the same way, if the bars are made ten times as small each way, the deflection will be ten times as great.

If, on the other hand, the bars received the proportion of heat due to their smaller surface—that is, one-quarter and one-hundredth in the two cases—then the deflections would have been one-half and one-tenth instead of two and ten.

Lord Rosse has obtained the effect of concentrating on the ends of small bars the heat which corresponds in quantity to the area of large bars by simply soldering the ends of a pair of very thin bars to the center of a thin disc of copper, the opposite face of which is blackened to receive the radiation. He found that with thin copper discs half an inch in diameter there is hardly any loss of effect, owing to the want of perfect heat conductivity in the copper. This plan has the further advantage that the soldered surface or junction is on the heated surface, and not, as usual, buried to a depth of a millimeter or so in the pile. In the latter case a superficial warming gives rise to currents which partly return at the back of the warm junction, so that the full current to the galvanometer is not produced until the pile is heated to the bottom of the junctions. Lord Rosse fully realized the advantage of small bars, a single pair of which he has used in his investigations on the heat of the moon. He has experimentally verified the conclusions which he found theoretically to be necessary, namely, that as the bars are made thinner the junction not only produces a greater effect upon a suitably arranged galvanometer, but, in addition, the final temperature, and therefore the steady current is much more rapidly developed.

For some purposes the smallest heat receiving surface is sufficient, as in the experiments of Dr. Huggins and Dr. Stone upon the heat of the stars. In this case the image of the star produced in the telescope is so small that all the heat can be brought to a surface no larger than the point of a pin, so here especially is a single pair, and that as fine as possible better than any pile.

By this reduction in the size of the bars one of the disturbing elements in the argument that has been used is made of less importance; I mean the effect of the resistance of the connecting wires. If the bars could be made so fine that their resistance would be equal to that of an ordinary pile, then the resistance of the connecting wires would, for the purpose of comparison, be eliminated.

Wishing myself to put this argument to the test of experiment, I devised and made a special form of junction on Lord Rosse's plan, but with bars made of the alloys already described far finer than have been used before. They have a section of about one-twelfth of a millimeter each. They are soldered at one end to a piece of copper foil about one-third of a square centimeter in area, and at the other end two large pieces of copper foil, separated by mica and pressed together. This is to ensure that the unexposed ends of the bars shall be at the same temperature, and that any uncertainty due to heat brought to one bar more than the other by the connecting wires shall be eliminated. As the bars are so fine that they could not carry the copper foil without risk, amounting almost to certainty, of being broken, I have had to support the copper foil independently by slinging it on stretched fibers of spun glass. These hold it securely, but do not carry heat away from it to any appreciable extent. Connecting this junction with the galvanometer that was made for use

with the pile of eighty pairs, a galvanometer which is not at all suitable, we found that a candle flame five feet away produced a deflection of eleven millimeters, or one-third of the deflection produced by the pile. The exposed surface was, however, only one-twelfth of that of the pile. It appears, then, that the pair with an unsuitable galvanometer did four times as well as the pile with its own galvanometer.

Mr. C. C. Hutchins has given a short account of an instrument which is simply a junction of steel and copper ribbon 1 × .03 mm. at the focus of a concave silver or glass mirror eight millimeters in diameter. He states, as a record of its performance, that the hand held six inches away produces a deflection of 30 divisions, and a lighted match at six feet drives the needle to the stops. I do not think Mr. Hutchins has done justice to the idea, for with such metal as steel and copper he might have made them far thinner, or with a thickness but little greater he might have used the alloys of bismuth, which have a thermo-electric power seven times as great.

It is necessary to use a galvanometer with a thermopile, and the delicacy of the former is just as important as the proper construction of the latter. In the first place, assuming that the ordinary form of galvanometer is to be used, the question arises, with what size of wire should the coils be wound? What is required is that the galvanometer should be so wound as to have some predetermined resistance, and yet have as many turns of wire as possible, especially near the inside, where each turn produces a far greater effect than one of the outer turns. Clerk Maxwell has shown that so long as the insulating layer occupies a small proportion of the space filled by the wire, which is nearly true in low resistance galvanometers, or that it has a thickness proportional to the thickness of the wire, the best effect is obtained when the diameter of the wire is made to vary in direct proportion to its distance from the axis. A coil so wound is said to be graded. Of course, in practice, a new size of wire is not taken for every layer, but a few sizes are employed in their proper places.

The next question that may be asked is, why should the ordinary size of coil be selected? Why should its interior or exterior limits be just those commonly used? Imagine two coils geometrically similar in all respects, but one of four times the dimensions of the other, then the number of turns in each will be the same, the resistance of the small one will be four times as great as the resistance of the large one, and the magnetic field at the center of the small one will for a given current be four times as great as the field in the large one. Now, to make the coils strictly comparable, they must each be made of the same resistance. If the number of turns in the small one is halved, the resistance will then become the same as the resistance of the large one, and so the same current will be sent through it as through the large by any pile with which it may be connected. The magnetic field at the center, however, will now be twice as strong in the small as in the large coil, and therefore the deflection will be twice as great. If the space occupied by both coils, so formed as just to fit within one another, were filled with wire, graded, and of such a size as to have the same resistance still, then the magnetic field at the center would be $\sqrt{5}$ or 2.24 instead of 2, that of the large one alone being considered unity; so the relative deflections produced in the three cases and the weights of the coils would be:

	Large coil.	Small coil.	Both.
Deflection	1	2	2.22
Weight	256	1	257

The figures given for the double coil hardly represent the best that could be obtained with such an extended coil, because the shape is not of the best; but, while a slight advantage could be gained by employing also the best shape, the figures are sufficient to show what a great advantage is obtained by reducing the interior of the coil, and how little is gained by enlarging it outwardly.

Since the needle or needles of the galvanometer must be suspended within the coils, it is evident that it is not possible to reduce the aperture in the coils without at the same time reducing the needle also. The question then arises whether shorter needles have any advantage. If the needles are reduced to half their length their moment of inertia will be reduced to one-eighth of the previous amount, while the magnetic moment will be reduced to one-half, or perhaps to rather more than half. If the controlling force which brings the needle to rest, whether due to a magnetic field or to torsion, is so modified as to give any definite period, then it will have to be proportional to the moment of inertia, and will, therefore, in the case of the short needle, be one-eighth of what it would have to be in the needle of double length; the consequence is that under these conditions—that is, of definite period—a given current in the coils will produce a deflection four times as great in the smaller needle. If both coil and needles are reduced in the same proportion, that is, to $\frac{1}{n}$ of the original size, then resistance and period remaining the same, the deflection due to a given current will be $\sqrt{n^3}$. The only reason why this general reduction of dimensions has not been made before is that as the needles are made smaller or shorter, the irregularities of the silk suspension become of greater importance, so much so, that with needles only half the length, and with the same period, the disturbance would be eight times as great, and so for other dimensions in the proportion of the inverse cube. As it is, with the ordinary size of needle used in the galvanometer, the effect of the silk is sufficiently obvious with slow periods, and so no good would result from further reduction, but rather harm. On the other hand, with a quartz fiber, the full advantage of the smallest galvanometer that can be made is readily obtained.

There is another question in connection with the galvanometer, namely, is it best to use an astatic combination or a single needle. If the astatic needles are each placed as usual within coils, then in a low resistance galvanometer the deflection would be only $\frac{1}{\sqrt{2}}$ or about 0.7 times as great, as it would be if the same current were passed round a single coil of the same size, and of the same resistance as the two with only one needle, provided the period of oscillation remained unchanged, or with a second needle outside the coil, the deflection would be rather more than half of this latter result. I have here supposed that the moment of inertia of the mirror is not more than a small fraction of that of the needle.

To put these conclusions to the test of experience, I have made a very small galvanometer, with a coil about the size of a three penny bit, with a triple needle within it. The needle was rather less than three-sixteenths of an inch long, and weighed, with a mirror and connecting stem, less than three-quarters of a grain. This was suspended by a fine quartz fiber three inches long, and I had no difficulty, partly by screening and partly by a counteracting magnet lying on the table, in almost immediately producing a period of as much as ten seconds. This little galvanometer was connected with the thermo element already referred to, which was exposed to a candle at five feet. The deflection obtained when the period of oscillation was about seven seconds was 67 mm., while with a period of ten seconds it was 126 mm. Since the heat received is exactly one-twelfth of that which would fall on the pile placed at the same distance which produced a deflection of 31 mm. on the standard pattern galvanometer, it is evident that with the same amount of heat the standard instrument would have produced a deflection of 2½ mm. only, and so it appears that the combination of simple element and very small galvanometer is from 26 to 50 times as sensative as the much more elaborate and expensive apparatus which is always used.

Though a single needle or a group of needles is certainly preferable to an astatic combination, where sensibility only is the object, or where disturbing magnetic changes do not occur, there is a great practical advantage in using an astatic system in most cases, because if there is a slight magnetic disturbance, whether due to natural causes or to the movement of iron in the neighborhood, the effect is by no means so marked when an astatic, or nearly astatic, combination is used, as when a single needle is suspended in a field where the earth's magnetism has been almost entirely neutralized by an adjustable magnet.

There is one other consideration on which I have at present only very lightly touched, and this is the time that elapses after the heat falls upon the instrument before a fairly steady reading can be obtained. This is generally determined by the mass of the junction or junctions which have to be heated. These go on rising in temperature until the loss of heat is equal to the gain. The greater the mass the longer in general is the time that must elapse before a steady temperature is obtained. In some cases, especially when the galvanometer needle has a long period and a slight logarithmic decrement, and when the mass of the thermo junction is but small, the time of coming to rest may depend chiefly on the galvanometer.

Mr. Burbidge and I have determined this time in the case of the various instruments referred to in this lecture. The figures are of necessity mere approximations. They are:

	Seconds.
Thermo-galvanometer	200
Elliot's pile and galvanometer	120
The small thermo-element and Elliot's galvanometer	30
The small thermo-element and the small galvanometer	60

These figures are important, not so much because if an instrument requires twice as long before a reading can be obtained than another it will also require twice the quantity of heat on this account, but because time is a very important factor when heat measures have to be made

under the usual variable conditions. If a measure can be made in half the time, the uncertainty of the position of rest due to changes of temperature which cannot be prevented, is certainly on the whole not more than half what it would be in the double time—it may be even less—and so the accuracy or degree of trustworthiness is greater in proportion as the time which it is necessary to wait is less.

Mr. Burbidge has prepared the following Table, which shows in round numbers at a glance the value of the several combinations described in this lecture:

	Actual Deflection.	Deflection. Heat Rec'd	Deflection. Heat × time
Thermo-galvanometer (with cone).....	1	1/16	1/16
" " (without cone).....	1/4	1/4	1/4
Elliot pile and galvanometer (with cone)....	3/4	1/2	1/2
" " " (without cone)....	1	1	1
Pair with Elliot galvan'met'r (without cone).	1/2	4	17 1/2
" small " (without cone).	2	24	48

The falling off of the figures in the second and third columns, where a reflecting cone has been used, shows that it fails to usefully reflect all the heat which falls upon it. It ought never, in my opinion, to be used when definite results are required. I do not lay any stress upon the exact value of these figures, especially those in the third column; but, taking the ordinary apparatus without a cone as the standard of reference, the figures are sufficient to confirm the conclusions to which the argument which I have followed in this lecture has led.

(To be continued.)

Mr. J. W. Helps on Extending the Consumption of Gas.

The following is a summary of a report, made by Mr. J. W. Helps, Engineer of the Croydon (England) Gas Company, to his Directors, in respect to plans matured by him for increasing the consumption of gas in that district. Premising our extracts by remarking that we are indebted to the London *Journal* for the same, Mr. Helps introduces his theme by calling attention to the powerful rival which coal gas now finds in oil, the increased employment of which for the lighting of shops, public houses, etc., in Croydon has been very noticeable. This has, of course, affected the consumption of gas, although there had not at the close of last year been any falling off. Comparing that year with 1883, there had, in fact, been an increase of 10.32 per cent. in the number of consumers, and of 26.50 per cent. in the quantity of gas burnt by each of them. Mr. Helps gives some statistics for the six years, 1883–8, which show that the position of the Company at the date of his report was due rather to the increase in the quantity of gas used by existing consumers for purposes other than lighting than to the spread of the use of gas as an illuminant. That there was room for an increase in this direction is shown by the fact that out of about 16,500 houses in the Company's district, gas was used in about 6,000 only, leaving 10,500 upon which to work. In 1883 there were only 246 cooking stoves on hire; in 1888 there were 778, or more than three times the number. These are quite independent of the stoves purchased outright either from the Company or from other dealers. When Mr. Helps made his report there were in addition a large number of heating stoves and gas fires in use, as well as upwards of 40 gas engines. He took 60 cases at random, and found that the average increase in consumption per customer due to the adoption of gas for cooking and heating purposes was 61 per cent. This explained the high increase on the average consumption, and to his mind pointed out two things—that not only were the Company failing to introduce gas to any extent into houses not previously supplied with it, but were actually losing part or the whole of the custom of those consumers who had already purchased it. It behoved them, he thought, to consider the reasons for this state of things, and the best means of effecting an improvement therein. Mr. Helps proceeds to discuss these questions as follows:

In the past there is no doubt that gas companies have practically held a monopoly in the lighting trade; but to-day such is no longer the case. Oil is cheaper, better and safer; and the lamps in which it is burned are so vastly improved that there is no gainsaying the fact that lighting by oil is at least as cheap and as effective as lighting by gas by the ordinary and old-fashioned methods. But have these facts been realized by gas companies, and have they arrived at the conclusion that they must enter into active and commercial competition with rival purveyors of illuminants? It appears to me that, so far, they have not done so, or, if at all, to only a trifling extent.

There are so many hindrances placed in the way that frequently it is a matter of no small difficulty to obtain a supply of gas. With the occupiers of the larger houses this is not perhaps so severely felt, either on the score of inconvenience or expense; for it is, I am glad to say, becoming the practice with builders to put into the better class of houses the necessary pipes and connections at the time of building, and to apply to the Company for a service pipe. But in smaller houses, such as those in the occupation of respectable artisans, etc., how difficult and expensive does the matter become. The house has to be fitted up, the service pipe laid in, and probably a deposit paid, before the would-be consumer can obtain his light. This necessitates a considerable outlay—probably more than the tenant can afford. Nor does the inconvenience end here. The gas account is collected quarterly, and, as a rule, the sum owing at the end of that period is a comparatively large one, and more than the consumer is able or willing to pay at the time it is demanded; for, in nine cases out of ten, such a thing as putting by a certain sum for this purpose weekly has never been thought of, or, if thought of, acted upon.

What a difference in the case of oil. A man purchases a good lamp for a few shillings, and his weekly supply of oil is brought to his door. Of course, it is well known that his trouble does not end here; for he has still to pay a certain amount of attention to the lamp daily. But surely it must be owned that the process of obtaining his light is infinitely simpler and far less expensive than it is with gas. Then take the case of a shop or public house. The tenant has gas, but wishes for a more brilliant effect than he is able to obtain from it as consumed through the ordinary burners. He probably has not many inquiries to make, or takes much trouble in carrying out his desire. An agent of some oil merchant, or firm of oil lamp makers, calls upon him; and by offering him liberal terms of payment, and by drawing a vivid picture of the advantages to be obtained, succeeds in selling him a handsome lamp, which in a short space of time, and at little expense or trouble, he has hanging in his shop or bar, throwing utterly into the shade the puny efforts of the poor gas burners, and naturally giving rise to the assertion that oil is both a cheaper and a more effective illuminant than gas—it being, of course, lost sight of that the very highest development of oil lighting is here being compared with a somewhat old-fashioned and crude method of gas illumination. Meanwhile the gas company has been content to look on at this process of substitution—suggesting no advice and making no offers of assistance toward obtaining an even better and cheaper effect through the medium of its own commodity. Of the after inconveniences of the oil lamps I will say nothing. Sufficient be it that the shopkeeper or the publican has obtained, with little difficulty, an excellent light, and that this light means the diminution of his gas account.

I think I have shown that it is much easier and less costly at the outset to obtain a light by means of oil than by gas. So far I have said nothing about electricity, as in Croydon but little has yet been seen of this powerful but expensive illuminating agent; but I believe that the same means which will, in my opinion, stop the spread of oil, will prevent the adoption of the electric light to an appreciable extent.

I will first deal with the supply of gas to those houses which are without it, and more especially those of a yearly rental below £30 per annum. Of these there are in Croydon a large number, and comparatively few of them (only about 21 per cent.) are occupied by consumers of gas. It may be urged that the occupiers of the smaller houses—for instance, respectable artizans—are undesirable as customers, not being permanently resident. But I find that those workmen whose habits are somewhat migratory do not themselves rent houses, but usually lodge with those who do; and it is with these latter that I propose to deal, and in the following manner. I would suggest that the Company should offer to supply and fix the necessary pipes and fittings to any house of a certain size from the occupier of which an application had been received—of course, upon the fulfilment of certain conditions. Now, the cost of doing this, including a three-light meter, one pendant for the front room, another for the back room, one bracket for the kitchen and another for the passage—all the burners being governed—would be about £3 10s. These fittings would be of uniform pattern, and stamped with the Company's initials. A sum of 8s. per annum would cover the rental of the above fittings and meter, and would necessitate a charge of 2d. per week, or 8d. a month. The fitting need not be undertaken by the Company's workmen, but might be let to a respectable and capable fitter or firm of fitters, who would, of course, be empowered to carry out on their own account any further work which the occupant might desire in addition to that which I have specified. To encourage the use of gas for cooking, I should like to see a small cooking stove sold to the consumer upon easy terms, and fixed without charge, or even lent free of cost. In an ordinary artizan's house it is estimated that the yearly account for gas consumed, including the before-mentioned 2d. per week, would be a little over £2. Of course, in all cases it would be advisable

to get the written consent of the landlord before interfering with the house, and his acknowledgment that the fittings and fixtures were the property of the Company, and not liable to seizure under distraint for rent. The accounts would be collected monthly, or even weekly; and I would suggest that this should, at any rate at first, be done independently of the ordinary collectors. For instance, the inspector would take the index of the meter, hand it in at the office, where the account would be made out and returned to him for collection. This could, I think, be done at odd times, and without much interference with his other work. The mode of payment might be by a commission, say, of 5 or 2½ per cent. The consumer would sign a weekly contract; so that the Company could, in the event of payment being delayed, close the account at short notice. There are in the market several prepayment meters, the use of which provides for the sale of any desired quantity of gas on payment being made in advance. This amount cannot be exceeded until a further payment has been made; and a very simple contrivance has been invented and patented by Mr. W. A. Valon, of the Ramsgate gas works, which promises to fulfil all requirements. Should this be borne out in practice, I would certainly recommend that meters of this description should be adopted in place of the monthly or weekly collections mentioned above. In the event of these suggestions being carried out, it would be well to advertise the proposals in the local press, etc., and to let it be known that the experiment would be made with only a certain number of houses—say, 100 or 200—and that applications would be attended to in the order in which they were received.

I then come to the question of providing improved lighting in those establishments where provision is already made for obtaining the necessary supply. I have before referred to the method adopted by purveyors of oil and oil lamps; and I would certainly recommend that the Company should follow somewhat on the same lines. The ordinary consumer fails to discriminate between a poor light arising actually from the bad quality of the illuminant, and one caused by the improper combustion of a gas of good illuminating power in a faulty burner or under unfavorable conditions. The one phrase, "bad gas," is applied in both cases. And here I cannot refrain from remarking that much harm is done to gas companies by the utter ignorance of the principles of their trade displayed by many so-called gas fitters, who, on being called in to investigate a complaint of a bad light, are frequently unable to recognize its real cause, and accordingly cover their ignorance by wild statements about the quality of the gas, and the prevalence of similar complaints. In nine cases out of ten, the Company's inspectors are able, by pointing out some defect in burners, globes or fittings, to prove the fallacy of such remarks; and either to provide for the consumer a sufficient illumination, or to point out to him the means by which such a result may be obtained.

Now, it is a fact that by simply changing the burner, or the burner and globe, it is possible to cause 5 feet of so-called 15-candle gas to give a light equal only to 5 or 6 candles, or to increase it to that of 50 or 60 candles; and thus, in the eyes of the consumer, to produce from identically the same article a bad light, a fairly good one, or an excellent or even brilliant illumination. But how are our customers to obtain the benefit of this fact? Well, my opinion is that our companies should take steps to provide a place where various kinds of burners could be exhibited, tested, and compared, and advice given as to the description most suited for the special requirements of the consumer. Again, it behoves the Company to deal very liberally in the matter of burners—to sell them as cheaply as possible, if not to actually give away the cheaper kinds. With regard to the more expensive burners—such as the Wenham, "Meteor," Schulke, Siemens, etc.—I believe much good would arise from actually canvassing for orders amongst publicans, shopkeepers, etc., and making offers to provide and fix these burners on approval. I may say that we have already tried this on a small scale, and almost invariably the burner has been retained, and not unfrequently others have been ordered—in many instances to the exclusion of oil-lamps, till then in use. Easy terms of payment might be offered—say, the addition of a certain sum to each quarterly account, to provide for the full payment within a specified time. This sum would also cover the bare cost of fitting if thought desirable.

Then comes the question of gas for cooking, heating, motive power, etc.; and I think there are few towns where greater progress in this direction has been made than in Croydon. This is, in my opinion, due in a great measure to the liberal policy adopted in letting out stoves on hire and fitting them up free of cost. In 1880 we had on hire 104 stoves; and in 1884, 277. In 1885 we commenced the system of fixing them free; and in the same year we held an exhibition of gas apparatus. In consequence, at the end of the year we had on hire 524 stoves; showing an increase over 1884 of 247 stoves, or eight times the increase of 1884 over 1883—viz., 31. On Dec. 31, 1888, the number had reached 778. These figures are, as already mentioned, entirely irrespective of those stoves either sold direct by the Company or purchased from other dealers. But when it is remembered that we have upwards of 6,100 consumers, and frequently one consumer has several stoves, it will be seen that there is considerable room for improvement.

Mr. John Somerville, in his presidential address to the members of the Southern District Association of Gas Engineers and Managers, in February last, said that during the summer of 1888 the South Metropolitan Gas Company held 20 exhibitions, with the result that the net increase of cooking stoves in use over the previous year was 2,192, or more than double the increase of 1887 over 1886. About 860 direct orders were received at these exhibitions; and during the last three months of the year, 257 heating stoves were sold direct from the Old Kent Road Offices. Now, I certainly think that another exhibition of gas appliances would be a great benefit to the Company, and would be the means of giving a much-needed impetus to the letting out and selling of gas cooking and heating stoves, etc., in the district. [This exhibition has since been held, with excellent results, and a large show-room, etc., is being erected.] But it is not enough to show the people who attend the exhibition the various appliances, and to tell them what can be done by their use. Something more is needed to keep the matter constantly before the public; and I cannot help reverting to a report I presented in November, 1887, in which I advocated the erection of show-rooms, etc., where the various kinds of stoves could be seen, and, if necessary, tested. At present our accommodation is far too small; and this fact, I feel assured, stands in the way of our doing such a business in the disposal of stoves, etc., as I think we could reasonably expect with improved facilities for bringing them prominently into notice. [This suggestion has been adopted; and a large show-room is now being erected.]

I wish now to bring before you what I consider to be a most important point, and that is the question of deposits. Of course, I feel that it is hardly possible to do away with them altogether; but I think that it is highly desirable that the system should be reduced to the smallest limits. On this subject I must again quote Mr. Somerville in the address already alluded to. He says: "I may mention that the South Metropolitan Company gave up asking for deposits from occupants of private houses last year, and I have returned about £10,000 in deposits to other customers; and the last half-year's accounts show £114 less bad debts—a proof that more efficient collection of accounts is equal to, or better than deposits." Again, Mr. George Livesey, in speaking at the meeting of the Commercial Gas Company, on April 5 last, said, amongst other things: "That system [*i. e.*, deposits] has been worked too much in times past. I think gas companies are quite aware of the fact, and they are not exacting such deposits now, where they can be avoided. The abolition of all deposits where possible, the giving facilities for services without cost to the consumers, and helping them in the way of fittings—that is what we should do. I think the time is coming when gas companies should supply fittings." And the Chairman, in noticing the above remarks, said: "As regards deposits, the Board of the Commercial Gas Company are quite alive to that point." A strong argument in favor of the abolition of the system is contained in a paragraph appearing in the *Journal of Gas Lighting* for April 9 [p. 667], which states that the Chairman of the Gas Committee of the Bolton Corporation said that, since the introduction of the new regulation abolishing deposits, they had attached service pipes to upwards of 1,300 cottages which had not previously been supplied. But even if, by doing away with deposits, bad debts were to slightly increase (which I do not believe would be the case), I scarcely think it would be difficult to show that the profits arising from the consumption of gas by those who object to use it on account of the levying of deposits, would considerably more than make up for any loss sustained, without taking into consideration the increased stability of the Company which would be brought about by the additional consumers. One thing is certain, deposits form a hindrance to the sale of gas, and every effort should be made to bring about their partial, if not total, abolition; but if such be accomplished, it is necessary to suggest some means of obtaining the result that their imposition is intended to produce. I will name the following: (1) Reference from other gas companies; (2) reference from bankers or others; (3) monthly or weekly payments; (4) prepayment meters.

Inspection of Cements.

Mr. F. Collingwood, C.E., contributes the following interesting remarks on this subject to a recent issue of *Engineering and Building Record:*

That continuous and careful inspection of cements before using is a necessity, few persons will dispute; but that it is often so conducted as

to cause needless trouble to contractors and others is, no doubt, equally true.

The subject may be looked at in two ways: *First*, as to what inspection on works of ordinary magnitude will insure a cement that can be depended upon to make sound and durable work. *Second*, on works of great magnitude, whether, by setting a high standard, it may be possible to *raise* the quality of the cement, and obtain a better article than was previously to be had.

The latter course was pursued by Mr. Grant, of London, in the sewerage work under his charge, and he succeeded in raising the quality of Portland cements far beyond what they had previously attained to.

But in all ordinary operations engineers and architects are satisfied if they can rely upon a certain standard of strength, upon which their computations are based.

As a rule, the cements of any neighborhood are well known, and have an established character. If we attempt to ask that *all* the cement furnished shall reach the *highest* strength that any sample has ever reached, we shall doubtless have trouble and plenty of it. If, however, we fix a limit which represents a fair average, we shall probably have no difficulty in obtaining it.

Two things which most frequently cause trouble are deterioration from exposure or age, and almost the contrary of this, in cements having considerable free lime, the *lack* of age. The Portland cements all require a certain amount of exposure in a dry place before use to prevent what is technically called "blowing," or expansion and cracking after setting.

Most of our natural cements do not require this, but any cement which heats sensibly in mixing does require it. As a rule, however, any cement which does this is open to suspicion.

Specifications should require samples from not less than every tenth barrel. These, with briquettes mixed with about 60 per cent. of the water required for a very stiff mortar, and tamped into the molds, should, for good natural cement setting entirely in the air, give in 24 hours about 60 pounds tensile strength per square inch. They will probably vary from about 45 to 90 pounds. If they set one hour in the air and 23 hours in water, they should break at about 40 to 60 pounds, the latter being rather above the average. At the end of a week the strength will be from 20 to 50 per cent. higher.

Pats made two to three inches in diameter and half inch to an inch thick, setting a short time in the air and then placed in water, should set without either cracking or falling down.

There is no necessity ordinarily of accepting cement of an unknown brand; when it is unavoidable and the work important, more extended tests should be made before any acceptance. The ordinary 24-hour test mentioned is sufficient to insure that the cement has not been damaged, and is usually sufficient.

A test for fineness of grinding is also desirable, if the highest results are desired. The best cements furnished are now such that only about 5 to 10 per cent. will be retained on a sieve of 10,000 meshes (of No. 40 by Stubbs' gauge wire) to the square inch.

It is customary in specifications for the use of Portland cement to prescribe that a supply sufficient for a given time (several weeks at least) be kept on hand and spread out in a dry place. As a large share of the Portland used in this country is imported it has usually sufficient age without adopting this precaution.

A sound natural cement coming up to the requirements mentioned will continue to increase in strength for several years, and for most uses answers every purpose.

It is needless to say that the cement which is strongest at the end of 24 hours is not necessarily so at the end of a year. All we learn by a short time test is, that cement of a *known brand* is up to its usual standard of quality.

Interesting Experimental Data from the Paris Gas Works.

M. Sainte-Claire Deville, the celebrated French chemist attached to the staff of the Paris (France) Gas Light Company, has made a most interesting report to the Company, in which he notes many important results from his varied practice at the works in recent years. He says:

1. Those coals which contain most oxygen are those which most readily absorb and retain moisture. When the oxygen ranges from 5½ to 12 per cent. the latter ranges from 2.17 to 6.17 per cent.

2. The whole quantity of volatile matter in coal is greater the greater the percentage of oxygen. When the latter ranges from 5½ to 12 per cent. the former ranges from 26 to 40 per cent.

3. The quantity of carbureted volatile matter (after deducting the possible water) is also greater the greater the percentage of oxygen in the coal. The respective ranges are: Oxygen, 5½ to 12; possible water, 6¼ to 13½; carbureted volatile matter, 23.23 to 30.83 per cent. of coal free from ash.

4. There is no clear relation between the percentage of cinders and the analysis of the coal. Still, the least oxygenated (5 to 6½ per cent. of oxygen) and the most oxygenated (11 to 13 per cent.) coals contain most cinders, and the least cinders (rarely below 3 or 4 per cent.) are in the coals which contain 6½ to 9 per cent. of oxygen.

5. There is no clear relation between the percentage of oxygen and the proportion of sulphur chlorine. That depends on the geological stratum, and probably on the circumstances of deposit.

6. When a coal is distilled with its own coke the yield of gas is less in the most oxygenated coal, because of the poorness of its coke. (Range = 10,641 cubic feet and 2,420° F., down to 9,691 cubic feet and 2,232° F.)

7. The more oxygenated coals are easier to distil; heated with their own coke they distil more uniformly than the less oxygenated, and at a lower temperature.

8. Carbonic acid diminishes lighting power by 2.73 per cent. for each per cent. of gas replaced by carbonic acid. (Date of research, September and October, 1886. Agrees closely with Mr. Sheard—Sept. 13, '87—who says 2.69.)

Nitrogen, similarly, causes a loss of 1.8 per cent.

9. As we pass up from coal with 5½ to coal with 12 per cent. of oxygen, we find that in the analysis of the gas produced the carbonic acid rises from 1.47 to 3.13; the carbonic oxide from 6.68 to 11.93; the hydrogen sinks from 54.21 to 42.26; the marsh gas and nitrogen together rise from 34.37 to 37.14; the benzol rises from 0.79 to 1.04 (at between 9 and 11 per cent. of oxygen in the coal) and again sinks to 0.88; the other (non-aromatic) carbureted hydrogens rise from 2.48 to 4.66 per cent. Heating the coal by its own coke, temperature produced sinks from 1,326° to 1,222° C.

10. Under the same circumstances the density of the gas rises from 0.352 to 0.482, and the lighting power rises from 8.03 to 10.3 candles (assuming, that is, that the Carcel is 7.435 English candles) per 5 cubic feet of gas actually collected.

11. Under the same circumstances the amount of absolute lighting power obtainable from a metric ton of coal rises from 227 to 269 Carcels. This rise is not proportionate to the increase in volatile matter; the reason appears to reside in the presence of carbonic acid.

12. The most bulky coke is that from coal containing from 5 to 7½ per cent. of oxygen.

13. Coke from coal with 5 to 7½ per cent. of oxygen is good, though rather quick burning; 7½ to 9, small and dense, excellent; 9 to 11, mediocre or bad; 11 to 13, "detestable."

14. Weight of tar increases from 3.902 to 5.592 per cent. of the coal used; weight of liquor increases from 4.584 to 9.861 per cent.

15. The production of ammonia depends much more on the temperature, the season of the year, etc., than upon the nature of the coal; explained by the accumulation of ammoniacal salts in the coke towers in winter.

16. In coal from the same seam, the more oxygen, the greater the yield of ammonia.

17. In ordinary working the distribution of the impurities is:

	NH_3.	HCl.	H_2S.	HCy.	CO_2
Retained in condensers, per cent.....	63.1	96.3	8.1	3.3	9.8
" scrubbers (sawdust) pr. ct.	35.4	3.7	3.8	5.2	7.5
" purifiers (iron oxide) "	1.5	—	88.1	91.5	Traces
Remaining in gas.....	Traces	—	—	Traces	82.7
	100.0	100.0	100.0	100.0	100.0

18. The best gas coals are those containing 7½ to 9 per cent. of oxygen. Less oxygen than this in the coal, there is plenty of coke but the gas is poor; more—the coke is bad.

19. As to the effect of the temperature of distillation, the Paris experiments of the last twelve years have simply confirmed the well-known statements that high temperatures (1) increase the volume; (2) diminish the density; and (3) lower the lighting power of the gas; (4) slightly decrease the carbonic acid (but not always so); (5) do not affect the proportion of carbonic oxide; (6) decrease the marsh gas; (7) diminish the percentage of heavy hydrocarbons, absorbable by bromine, other than aromatic hydrocarbons; (8) increase the hydrogen; and (9) decrease the yield in tar. The increase in volume is greater within limits than the decrease in lighting power; so that the ton of coal gives *more light*.

20. If the gas issuing from a retort be made to record its own yield by means of a pencil and rotating cylinder, the curve recorded presents a marked inflection where the yield of gas becomes exhausted. If the heat be adjusted to suit the charge and the time the yield is very steady until just before the end of the four hours. If the temperature be excessive, or if the coal be too highly oxygenated for the average heat applied, this inflection is very strongly marked. If the temperature be inadequate, the inflection is less well marked.

(Concluded from page 600.)

[OFFICIAL REPORT.—REVISED BY THE SECRETARY.]

Seventeenth Annual Meeting of the American Gas Light Association.

HELD AT BALTIMORE, MD., OCTOBER 16, 17 AND 18, 1889.

SECOND DAY.—MORNING SESSION.

The President—The first paper to be read this morning will be that by Mr. W. H. Pearson, of Toronto, Canada, on

THE CONDUCT OF THE ELECTRIC LIGHT BUSINESS IN CONNECTION WITH THE GAS INDUSTRY.

Mr. Pearson—I will state, before commencing to read my paper, that I have made one or two alterations in it, relative to the percentages and statistics given of the gas companies of Massachusetts. When I prepared my paper I did not notice that there were a number of lists of those companies, and I took a list which was not complete. That will account for the differences which you will find in the percentages.

The question of the desirability of a gas industry, in connection with the electric light business, being operated by the same company, is one regarding which, there will naturally, be considerable diversity of opinion, and one, indeed, upon which, I am free to admit, I have been induced to change my views. At the meeting of this Association, two years ago, I strongly opposed gas companies having anything whatever to do with electric lighting, but further and fuller light upon the subject has caused me to think differently, and I have recently come to the conclusion, that, on the whole, it would be advantageous for a gas company to manufacture and sell both kinds of lights; and it will be my purpose, in this paper, to advocate that side of the question. In doing so, however, I I must express my regret that, owing to the strange course taken by the Toronto City Corporation, in refusing the Consumers' Gas Company the right to use the streets for electric wiring, I am not in a position to speak from practical experience in electric lighting, but as doubtless there are gentlemen here who have had this experience, they will be able to supply information which I am unable to give.

The rapid progress which has been made in electric lighting during the past few years, and which is continually going on at an increased ratio, must of itself be conclusive evidence to any unprejudiced mind that it has "come to stay," and that, as at present, it is destined to continue to be one of the principal, though not, in my opinion, the chief lighting agent of the future; for on careful investigation I am satisfied that neither the arc nor the incandescent light can compete with good and cheap gas, as the light for the people, and while there are some who can and will have luxuries, or what they consider to be the best, at any price, with the general public the question of cost is the factor which has the most weight.

Admitting that electric lighting is to be a permanent industry, and that it will have a field that would otherwise be occupied by gas, why should not the two systems be conducted under one management? My first reason for claiming that they should be is that a gas company would be able to furnish the light more cheaply than an independent electric light company would in the same place. A gas company must have an executive head, who is usually a man of sound judgment and intelligence, with a good practical knowledge of the various mechanical and other appliances, including the economical production of steam, and having experience in the purchase of supplies and of the best markets in which to obtain them and also having a large experience in dealing with the public. He is, therefore, in these respects, better qualified to supervise the operation of an electric lighting business than a novice. The gas company being already organized and officered, the combination of electric with gas lighting would cause comparatively little or no additional expense for the directorate and management, and the two businesses could be much more economically conducted. Again, in most gas works, there is generally ample space in the grounds for a building, or, what is better, room in a suitable building already erected, in which to erect an electric light plant; nor will any additional office room be required. The saving in the interest on the cost of these buildings therefore, would alone, amount to a considerable sum, while the opportunity for the profitable utilization of some of the by-products of the gas business, would be another item of saving.

To my mind, however, the most important reason for a gas company going into the electric lighting business is to head off ruinous competition.

We all know that, when seeking to obtain a foot-hold in a city, the first thing the promoters of an electric light company do, is to systematically and persistently canvass the gas consumers, and offer to supply them with their light, say, for a certain period, at the same price they have been paying for gas, and sometimes at almost any price. By this means, they often succeed in obtaining a large number of customers, who otherwise would not have adopted the electric light, and when, at the end of the term of agreement, the electric light companies are driven to increase their price to an amount that would pay a fair interest, the consumers, having gone to the expense of wiring and lamps, and disliking to have to "knuckle down" to the gas company, sometimes keep a number—if not the whole—of the lights, which otherwise they would not have retained. Now, if the gas company had had control of the lighting, they should not, and probably would not have sold the light excepting at a fair profit, and to supply a legitimate demand, and consequently would have retained a number of their consumers, lost through this ruinous competition. Again, if the electric light business was in the hands of the gas companies, corporations would not put up electric lights in the reckless manner they do now, at three or four times the cost of gas, simply because the companies offering them are in opposition to the gas company, or because of the persistent importunity and the powerful influences brought to bear upon them by these opponents of gas. There would, therefore, be fewer electric lights and more gas lamps—much cheaper, and, at the same time, quite as effective street lighting—and, consequently, the interests of both the citizens and the gas companies would be promoted.

The circumstances of a company will determine the degree of the importance to it of going into the electric lighting business. It is, of course, usually much more important for a small company to adopt electric lighting than for a large one, owing to the necessarily high prices charged for gas rendering electric lighting competition more injurious. Again, a gas company having full employment for all of its plant, and contemplating extensions, will be in a much more favorable position to operate the electric light than one with ample space and apparatus for a much larger business, as, instead of extending its gas business, it could adopt electric lighting, while in the latter case, the introduction of the electric lighting plant would continue to keep their superfluous gas plant without employment.

An important enquiry here presents itself:—Would gas companies adopting the electric lighting shut out all opposition? That would depend a great deal upon the financial strength of the company, and the manner in which it has conducted its dealings with the public. Few local electric light companies would be willing to "tackle" a gas company, strong financially, provided the latter's prices for electric light are fair and reasonable, and it is prepared to supply every legitimate demand.

As opposition in lighting has proved to be productive of unnecessary and wasteful expenditure, and consequently detrimental both to the interests of the gas and electric light companies, as well as to the public, I hold that the civic authorities should, with certain restrictions and safeguards, give the monopoly of the electric lighting, as well as the gas, to the first in the field, thereby securing to the citizens the cheapest light they can obtain: for, as experience has shown, ruinous competition has almost invariably resulted in combinations and increased prices, owing to the necessity of having to pay interest upon the large amount of unnecessary capital, and to make up for previous losses. I am afraid, however, that it will be a long time before corporations will learn this common-sense lesson.

I do not wish it to be inferred from anything that I have said that I contemplate, from the opposition of electric lighting, anything approaching disaster to any fairly large and well organized gas company, or to any company in a position to sell gas at a moderate price, and, drawing my conclusions from what has already transpired, am satisfied that with regard to such companies the worst that could happen would be a reduction in the ratio of increase in the business of the company heretofore maintained, or the maintenance of the *status in quo*. After a good deal of enquiry, I have failed to hear that any good sized company has failed to maintain at least the consumption of the previous year.

As the admirable report of the Board of Gas Commissioners for

the State of Massachusetts, for the year ending June 30th, 1888, may not have been accessible to most members of this Association, some extracts and deductions from that report, in corroboration of my claims, will doubtless be of interest. This report contains the statistics of 60 coal, and 10 oil gas companies, and 48 electric light companies. The names of 70 companies being given in addition to 12 gas light companies operating electric lights. Fifty of these coal gas companies show an average increase in the consumption, over the preceding year, of 12.68 per cent. For three there are no returns showing increase or decrease, and seven show a decrease in the consumption. Four of the oil gas companies show an average increase of 13.64 per cent.; for two there are no returns, and four show a decrease. Electric lights are supplied in thirty seven of the places where there are gas companies, and the average increased consumption shown for these gas companies is 11.85 per cent., there being only seven gas companies where there are opposition electric light companies that show a decrease in consumption. It is to be regretted that the increase or decrease in the electric light business is not given in the report referred to. Twenty-seven of the Gas companies referred to had during the year reduced the price of gas, 20 of which are opposed by electric light companies. That in the aggregate these gas companies are doing a fairly paying business, and are in a sound financial position, is evident from the following facts. The dividends paid by 64 of them, range from 0 to 20 per cent., and average 5.15 per cent. The report of the other six is not given. The aggregate surplus and reserve funds of these companies amount to 23 per cent. on the paid up capital. With one exception, the companies not paying dividends are very small ones. The following statement will, to some extent, show the nature of the competition with which they have had to contend: The average price charged per hour for a 16-candle incandescent electric light, for commercial lighting, in the cities of Boston, Cambridge, Lawrence, Lowell, Springfield and Worcester, is 1.28 cents, which is equal to $2.56 per thousand feet for gas of the same illuminating power, while the average price charged for gas in these places is $1.48 per 1,000, the average price for nominal 2,000 candle arc lights for municipial lighting, all night, being 55 cents. The average increase in the consumption of gas in these places, over the previous year, amounted to 9.47 per cent. These are fair samples of the electric lighting charges made throughout the State, where water power is not employed.

From the above statements it appears evident that gas lighting is more than holding its own in Massachusetts (and I take it to be a fair illustration of the position of the industry throughout the United States) and that incandescent lighting cannot there, at all events in the larger cities, begin to compete with gas in price. Whether or not electricity, at the prices charged in Massachusetts, is paying, does not appear, as there is no statement in the report referred to of dividends paid by electric light companies, as in the case of gas companies. This, of itself is suspicious, as if fair dividends were paid, it is not likely that the fact would be suppressed.

While I am an advocate, for the reasons above given, of gas companies adopting the electric light, I should be sorry to have it understood that I yield to some of the claims to superiority made by the promoters of electric lighting. That it does not vitiate the atmosphere, throws but little heat and does no injury to decorations, plate, etc., I am quite prepared to admit, but the vitiation of the atmosphere, by properly purified gas, is by no means as serious, nor as injurious to decorations, etc., as is sometimes claimed by its opponents, and while the electric light does not vitiate the atmosphere it cannot be utilized in ventilation as gas can. The advantage or disadvantage of the heat thrown out by gas is really a matter to be determined by the kind of climate in which it is used. In the northern parts of the United States and in Canada there are only two or three months in the year in which the heat of the weather causes any annoyance, while, during the rest of the year, the gas is found to be a positive advantage in supplementing the heating from other sources. As an illustration that this is recognized by gas consumers, one of our largest hotel keepers told me recently that it prevented his having to light his furnaces weeks earlier than he otherwise would, and this, he said, was one of the reasons why he did not care to put in the electric light; and it was only a few days since that another of our customers declined to put in the electric light, because it would necessitate his putting a heater into his restaurant.

As to steadiness, we all know that a perfectly steady light can be obtained from gas by the use of proper globes and by many of the different kinds of burners, and that the gas light is not subject to the deterioration which takes place in incandescent lights, often after the lamps have only been in use for a few days, nor to the fluctuation in the candle power of the arc lights. Nor am I prepared to yield the palm to electricity for street lighting, as I am satisfied the streets can be as effectively, and in many places more economically illuminated with gas. For instance, two high candle power lamps, consuming 20 to 25 feet of gas per hour, placed 200 feet apart, though not giving as brilliant illumination around the lamp, will give a more satisfactory lighting than so-called 2,000 candle—(actually from 400 to 500 candle power)—arc lights placed 400 feet apart.

An important element to be considered is the question as to whether the cost of the production and the selling price of electric lighting can be materially reduced.

Unfortunately, in discussing this point, not being an electrical expert, I am placed at a disadvantage, but I think we have some data to enable us to come to a fairly accurate conclusion. It is hardly likely that the high efficiency of the engines used in many places (using say less than 3 pounds of coal per horse power) can be much improved upon, or that the very low prices of carbons (now less than a cent each) can be much reduced, while the introduction of the alternating system of incandescent lighting seems to have reduced the cost of wiring to a minimum. It is pretty generally admitted among electricians, that a 2,000-candle arc lamp requires one horse power, and 14 is about the highest number of 16-candle incandescent burners obtainable per horse power, that I have known to be claimed. Whether better results than these can be obtained is a matter for consideration.

It does not, therefore, appear as if there could be any very important reduction made. Moreover, it is admitted, that in numerous places, the electric lighting business had not been a profitable one, and certainly, higher prices will have to be charged in those places to put it upon a paying basis. At all events, as an offset (as far as large cities are concerned) against the probable reduction in the cost of production, the probability that the authorities will require wires to be placed underground, which means about three times the cost of overhead wiring, must be taken into consideration.

It must be admitted that the prices now charged by manufacturers for electrical apparatus are generally far too high, and, doubtless, a very material reduction will be made, in the course of time, which will score in favor of electric lighting.

The use of electric motors is, of course, a valuable adjunct to the business of incandescent electric lighting companies, and one which will doubtless increase, and, therefore, a factor to be taken into account.

It must not be lost sight of, however, that important reductions and savings are constantly being accomplished in the manufacture and distribution of gas, and that there is equal probability of their fully keeping pace with the reductions made in the cost of electric lighting.

A consideration of the prices paid for electric lighting throughout the United States generally will not be out of place, and this information is furnished by Whipple, in his "Municipal Lighting (1889)." In this interesting volume, he gives a list of the prices charged for public lighting in 316 cities and towns in the United States, where the streets are wholly or partly illuminated by electricity, of which the following is a partial summary. The highest price paid for an arc light of 2,000 nominal candle power, burning all night, is $360 per annum and the lowest $40. Between these two extremes, are 186 prices, a few of which I give below: $280 per annum (56 lamps); $255 (100 lamps); $252 (44 lamps); $237.25 (704 lamps); $233.60 (25 lamps); $200 (170 lamps); $60 (100 lamps); $85 (65 lamps); $80 (14 lamps); $75 (33 lamps); $73 (20 lamps); $60 (55 lamps); $57.60 (75 lamps).

The highest price charged for lamps burning till *midnight*, is $273.73, and the lowest $47.00 per annum, and the following are a few of the intermediate prices charged: $196 (56 lamps); $182.50 (17 lamps); $146 (16 lamps); $75 (55 lamps); $75 (22 lamps); $60 (26 lamps); $50 (17 lamps).

The difference between the highest and lowest prices charged for lamps burning all night, is 482 per cent., and between the highest and lowest for lamps burning till midnight, 386 per cent.

It is clear that no local conditions could legitimately cause anything like such a great variation in prices of electric lighting. It

would seem as if electric light companies simply obtain the highest prices they can get, and for the sake of "getting in," would take any price, and that it is largely a matter of shrewdness on the part of the officials on both sides, as to the price paid.

It is evident these highest and lowest prices cannot be maintained; and the question arises, when they come down to a fair average, say $146 per annum, or 40 cents per night, will there not be a reaction in a number of places in favor of gas lighting? Whipple gives the average cost for arc lighting, as $121 per annum, but from information which I have, I think 40 cents per night would be a fairly paying price, where a large number of lamps are taken, and I consider at that price, high candle power gas lamps come into successful competition and give a more satisfactory illumination.

From careful enquiry and investigation, I am satisfied that, in the average place, incandescent lighting cannot be furnished to pay a moderate dividend, at less than one cent per hour, for a 16-candle lamp, which is equal to gas at $2.00 per 1,000 feet. In the city of New York, I am informed that the Edison people are charging 1½ cents per hour, which is equal to gas at $2.40 per 1,000 feet, and that they pay a dividend of 5 per cent., and their stock is quoted at $75 per $100; I also understand that in their down town station their business is not increasing.

To conclude, I consider that if a gas company can obtain the control of electric lighting, by all means let it do so, but if it cannot I do not think it has any very great cause for alarm or discouragement; for, I am satisfied, as regards most places, that if proper attention is paid to the introduction of gas for heating, cooking and motive power, the increase in consumption from these sources will more than compensate for the loss owing to the introduction of the electric light. As far as the Manager is concerned, it need not personally be to him any source of regret; for, as a rule, there is quite enough in the gas business to occupy his energies to the fullest extent, and that the wear and tear from it is quite sufficient, without the addition of that which must of necessity arise from the adoption of electric lighting.

Discussion.

The President—This is a very interesting and instructive paper. I suppose many of our members already have both systems running, and others are thinking of taking up the electric light business. I hope the paper will receive very full discussion.

Mr. Robert Young—Does Mr. Pearson think that, where an electric light plant is already established, whether a gas company can successfully compete by saddling an electric light plant on their own works? That is, whether a gas company can compete in electric lighting with an electric light company already doing business in the same city.

Mr. Pearson—I would think not.

Mr. Robert Young—It seems to me, such an increase of competition would only have a tendency to increase the cost of electric lighting, and that would affect the price of gas. Of course in a city where no electric light plant is already established, and the city desires the electric light, I would say it would be better for the gas company to supply that light than to allow a competing company to do it. But I do not think it would be advisable, where there is an electric light plant already established, for a gas company to enter into competition with them.

Mr. Stiness—Did I understand the question of Mr. Young to be whether it was advisable for a gas company, where there is an electric light company already established, to enter into the business of electric lighting either by its own corporation, or by consolidation with a company already established? I understood Mr. Pearson to answer in the negative. To that answer I desire to take issue. Although there may be individual cases where such a course may not be advisable, yet in our own New England I can scarcely name upon my fingers the instances where such a combination or consolidation has not been for the financial interest of the company as well as for the benefit of the people. I know by experience that there are many companies doing a very successful electric light business, and doing it in a way that gives the most perfect satisfaction to the public, by reason of the fact that they give all the means of artificial illumination, whether by gas, by the arc light, or by the incandescent light. In the report of the Gas Commissioners of Massachusetts (which I consider one of the ablest papers that has been yet published in the gas world) I find no mention is made of the increase of business; and I suppose that that omission arises from the fact that electric light companies have not been compelled to report to the Commission until within the past year, and, therefore, there has been no chance perhaps to make a comparative statement. But I think it comes to the mind of every man present here that the electric light business in Massachusetts is vastly increasing. I know this because I am a member of an electric club where these matters are brought to our attention; and I know that in very many cases this business is being done at a profit. Mr. Pearson quotes from Mr. Whipple's book the statement that in one instance $360 per year is paid for an arc lamp burning all night. I would like to furnish them for $130, and at that price will agree to pay a ten per cent. dividend. I would like to know where that place is. I think it is quite a remarkable statement. Mr. Pearson has given us some facts in his paper which come clear down to the present time and to rock bottom. I think that 40 cents a night for an arc light all night long is a good paying price. Mr. Whipple's book may be quoted as an authority by some, but I attach very little value to it. I think that the consolidation and combination of gas and electric lighting, taken by a gas company in its infancy, has proved a blessing to all. While perhaps it may not be appropriate here to give an exact statement as to cost, yet there is one matter which I think has been somewhat exaggerated. We know that in our gas business we charge a good price for the depreciation of our plant, yet I think that the depreciation in the electric lighting, say perhaps, in overhead wires, will compare most favorably with the depreciation of any gas plant. I have machines which have been running and wires which have been strung for more than five years without one single cent of expense for repairs. Undoubtedly in many companies which were organized simply for the sole object of selling a plant, and where they schemed and planned for the sake of selling stock, the depreciation may be very large; but where a gas company establishes a plant in the same way that they establish gas works—for all time—the amount of the depreciation and repairs will compare very favorably with those of a gas plant. I believe from my own experience there are many places where to-day the business of electric lighting and of gas lighting can be carried on with profit to the company, by one company. There may be individual cases where this cannot be done with a profit; but I think they are the exceptions. I think experience teaches us it is best for the gas companies to control, as far as possible, all means of artificial lighting, except what is burned by the wick.

Mr. Pearson—I find that Whipple does not give the name of the company charging $360; but here is his statement: "The highest price paid for an arc light of nominally 2,000 candle power, burning all night, is $360." I have the names of the places that I found in his list and of some others where a high price is charged, and if desired I can give them to you. In Rutland, Vermont, for 56 lamps, $280; Savannah, Ga., $255, for 100 lamps; Sacramento, Cal., $252, for 44 lamps; Boston, Mass., $237 for 704 lamps.

Mr. Stiness—I do not see why I need say a word for the good city of Boston, but I think I may make the statement that I am positive they are not allowed to erect a pole in the city of Boston. Every particle of wiring in that city has to be done upon the tops of buildings; and to maintain those wires upon the tops of those buildings requires a corps of men that is perfectly astonishing. That is a reason why in Boston they are compelled to pay that high price. Being a Massachusetts man I want to stand up for Boston; but what is said as to the high price paid in Boston does not alter the position which I have taken.

Mr. Littlehales—I entirely differ from Mr. Pearson and Mr. Young and agree with Mr. Stiness as to the desirability of a gas company going in for electric lighting, even where another concern is in possession; and I will tell you why I think so. We know that in most cases the same tactics have been pursued in starting electric light concerns that have been in many places, in past times, adopted in respect to gas companies. They have been started by speculators, and the plant has cost three times what it should have done. Within the past five or six years great progress has been made, by reason of which the apparatus for producing the electric light has been cheapened, and the efficiency of electric light plants increased, so that to-day a gas company, or any one else, can buy a plant of any given capacity for one-half what it would have cost seven or eight years ago. A gas company going into the business now has all those advantages. And those advantages are not small ones. I am at the present moment making application to the City Council of our city for permission to go

into the electric light business, and we think we can see our way to a fairly remunerative trade. During my trip around in investigating that matter I came across a number of gentlemen who have had a very large experience in electric lighting, and I think that those gentlemen can furnish this Association with a great deal of valuable information if they can be induced to speak on the question. I may mention Mr. Chadwick, of Lockport, New York, and Mr. Faben, of Toledo, Ohio. Both of those gentlemen are in the electric light business, and I have no doubt can give us a good deal of information on these subjects.,

Mr. Robert Young—Is it not to the advantage of the gas company, when speculators come into a town and expend a great amount of money in an electric light plant? They will have to charge more for their lights or make their stock of no value. The gas company might be able to put up an electric light plant that would be able to compete with them, but it would be done at the expense of the gas interest. I would be inclined to let the company with the large capital alone, for when a company has a large amount of money invested they will lose a good deal before they will give up.

Mr. Robert Baxter—I have listened with a great deal of interest to Mr. Pearson's paper, and also to the remarks of others. It is very pleasing to me to find that both Mr. Pearson and Mr. Littlehales have come around to the position which I took two or three years ago. At that time I sent a circular letter to the principal gas companies of the Dominion, placing several questions before them, and I had replies from them all. I think, with the exception of St. John, New Brunswick, they all said practically this: "We have enough to do in the gas business; there is no money in the electric lighting business; they are making no money; they are going to the bad; and we have enough to do in attending to our own business of making gas." I am glad to find that they have now come around to the position which I took then—and it is the strongest reason which I have for advocating a gas company conducting an electric light business as well as its own. That, if the public want the electric light they ought to have it; and if they want it who can give it to them as cheaply and as efficiently as a gas company? I maintain that no new company coming into the field is so well-fitted to do the business as a gas company already occupying that field. These points have been brought out most admirably by Mr. Pearson in his paper, and I need not take your time in going over them.

In reply to the question as to whether it is expedient for a gas company to go into the electric lighting business in a city where an electric light company is already established, I differ from Mr. Pearson and agree with Mr. Stiness. That is practically what the company I am connected with is about to do. Of course every company must be governed by the peculiar circumstances in which it finds itself. We were threatened with the species of persecution which has been so potent in the States. A company of "booming speculators" came to the town and organized a company with the deliberate intention of absorbing our company altogether, by buying us up, or buying us out, or forcing our stockholders to sell their stock below par and so enable them to gain control of the company. Under those circumstances my company decided to fight them with their own weapons, and, therefore, we installed an alternating system of about 1,500 lights, and are now running between 1,200 and 1,400 lights very successfully. We had, as I say, to fight them with their own weapons. We supplied the light at a very low price. I think that is the ground that gas companies ought to take, and I am glad to know that the number of those who are engaged in both businesses is increasing very rapidly.

Mr. McMillin—I am delighted to see with what facility gas companies can adapt themselves to the changed conditions of the times. Four or five years ago to mention water gas before a gas convention was like shaking a red flag before a bull's eyes; but to-day we all take it. A year or two ago perhaps, certainly two or three years ago, you could hardly find in a gas convention an advocate of electric lighting; and I believe that my friend Pearson told us at New York, two years ago, that we had better let it alone.

Mr. Pearson—I confess that in my paper.

Mr. McMillin—Now, I think that the most of us will agree that the electric light is a right good thing to have about; and now the only thing that will stir up the Convention is to mention fuel gas; we will get there also after a while.

In St. Louis there are now five electric light companies, and that, too, after five companies had combined into one united company. Myself and associates, as individuals, bought the united company, and we also bought the Heisler Company, and as the owners of the gas company we are now putting in a plant to do lighting, in competition with ourselves. So that we go farther than any one who has been talking here; for not only is the gas company putting up an electric light plant when there are already other plants there, but the President of the gas company is putting in an electric light plant in opposition to an electric lighting company in which he is himself considerable of an owner. I mention this matter because in negotiating for the purchase of the property there I became familiar with some figures which show what the electric light companies have been doing. Last year one little company, with $100,000 capital (which certainly could not have had much water in it), earned a clean 20 per cent. dividend. The United Company earned 18 per cent. There were four gas companies there, and I need not tell you that they did not earn 18 nor 20 per cent. There are now five electric light companies in the city, and some of them do a very large business. The Missouri Incandescent Company (the Westinghouse System) is branching out to do an extraordinary business. The President told me the other day that they had 18,000 lights on their books. The Laclede Company is putting up a 5,000 light incandescent plant. Another company has a 2,000 to 2,500 arc light plant; and this company is also putting up a 25,000 light incandescent plant, but which is not yet in operation. In the face of all this, the four gas organizations (which are now practically one) have had an average increase during the summer and fall thus far, of from 8 to 14 per cent., in the sale of their gas.

Mr. Pearson—How much does the electric light company which is making from 18 to 20 per cent. charge for their light? And is it an arc light company?

Mr. McMillin—The company that made 20 per cent. is an incandescent light company. They make private contracts, and there is no very sure way of knowing what they have charged heretofore; but they have been in competition with the gas companies, and with other electric light companies, and yet they have charged enough to get 18 or 20 per cent. out of it. Their charge depends somewhat upon the size of the customer. It is pretty cheap to hotels.

Mr. Pearson—About what is the average?

Mr. McMillin—Probably 75 cents per month for an incandescent light. The Arc Company charged 50 cents a light for all night lighting—for private or commercial lighting. For railroads (and they did a considerable portion of the lighting for the railroads) I believe they got $85 per year. That was not for all night, but on moonlight scale. Of course some of them burned all night, and for those they *probably* get $120, or something like that. The prices probably would be an average of the country. In this connection I want to say that I think it would be easy if all these cases of extremely low prices mentioned were investigated, to find a cause for them. I know of one town where they put in 50 lights for $48 each per year, just simply because a number of electric light companies were trying to get in there in competition, and the City Council was willing that one more company should come in. They asked for bids on 50 lights under promise to give the charter to the company that would bid the lowest. The old company bid down to $48; so none of the new companies got the contract. Of course the old company could afford to furnish those 50 lights for nothing rather than have a new company come in. I think you will find that all the extremely low prices are occasioned by something of that kind. I think that 40 or 50 cents per light, per night—in most parts of the country—is a very good business for the electric arc light. I am like my friend Pearson, I consider that 40 cents per night for the arc light is as good as gas at say, 75 cents or $1, per thousand feet.

Mr. Stiness—I move a vote of thanks to Mr. Pearson for his paper, as I consider it one of the very ablest papers we have had before our Association. [The motion prevailed.]

Report of the Committee on President's Address.

Mr. A. C. Humphreys, Chairman of Committee on President's Address, presented the following report, which was on motion of Mr. Graeff, received, and the recommendations adopted:

Your Committee to which was referred the President's Annual Address have considered the points and recommendations therein made, and would now commend to the members a careful re-reading of the address and a special consideration of the views expressed as to the conduct of the gas business so as to insure the full extension of our business.

Your Committee recommend that, following the suggestion of our President, the Council be instructed to promptly appoint a Committee of seven, five of whom shall be members of the Council to represent this Association, and with the representatives of kindred Associations, to consider and take action for the proper representation of the gas industry at the Centennial Exhibition of 1892. Your committee recommends also that the committee so appointed be authorized to officially represent the American Gas Light Association at said Exhibition, and that the actual expenses of this committee be paid from the funds of the Association under the direction and control of the Council.

Your Committee recommends that the Council be instructed to consider the question of proper co-operation between the several gas light Associations of America and take such action and make such recommendations as may by them be deemed advisable.

Your committee recommends that the usual action be taken by the Secretary looking to the preparation of suitable minutes in reference to the members deceased during the past year.

Your committee finally recommends that the necessary number of copies of the President's Address be printed as promptly as convenient, and two copies be mailed to each member of the Association.

ALEX. C. HUMPHREYS,
J. P. HARBISON,
J. L. HALLETT,
Committee.

The President—We have time to listen to the reading of another paper before taking our recess, and I will ask Mr. Lansden to read his paper on the

ADVANTAGES OF SUPPLYING A MIXTURE OF COAL AND WATER GAS.

The subject on which I was requested to prepare a paper is "The Advantages of Supplying a Mixture of Coal and Water Gas." I did not think, when I wrote our worthy Secretary that I would furnish a short paper on this subject, that the first matter I should have to speak of, would be one of the great "disadvantages" we who are furnishing a mixed gas labor under. It is this. We have no standard burner by which our candle power is measured. This is, of course, the most important question, when we wish to compare results. I believe there is no official recognition of any one burner in this country, for testing water, or mixed gases. Some municipalities have officially said that the gas shall be tested by a burner best adapted to the gas furnished. This leaves the question to be settled by the gas inspector of that locality.

The jet photometer, which is unreliable enough for coal gas, is vastly more so for testing water or mixed gases. Situated as we are, in Washington, we certainly have not a fair show in this regard. It is a statute law of the United States, that the Washington gas shall be tested by a fifteen hole Argand burner, which was done away with in England 16 years ago, when the 24 hole burner was adopted for testing coal gas.

Between the burner used in New York city and the one in Washington, there is something over 6½ candles. I think it unfortunate we have no recognized burner for testing water or mixed gases in this country. In the tests I give in this paper, of candle power, I used the Bray Slit, No. 7.

I will now speak of what I think are some of the advantages of of supplying a mixed gas. In localities where your consumption is subject to much fluctuation, and you are supplying a straight coal gas, you are compelled to keep under fire enough benches to furnish your greatest possible demand. When you have a water gas plant in connection, you may at all times keep your coal benches running to their utmost capacity, being able to supply your fluctuating demand from the water gas. Those only know who are making coal gas the worry and expense of half charges, idle benches, and the many changes they have to make to keep pace with dark days and rainy nights, when the moon should shine. I find our coal benches last much better and the results are much more satisfactory when we can keep them under an even fire, and doing full work all the time. This is vastly so, with recuperative benches.

One of the greatest advantages in supplying a mixed gas, is that of being able to furnish at all times any candle power required. I know it is impossible to furnish straight coal gas over 18 candle power that will give entire satisfaction to consumers, I presume that 90 per cent. of the gas consumed is burned in batswing or fishtail burners. When you go beyond 18 candle power, and often ess, consumers complain that your gas smokes. I admit much of this trouble is with the consumer. If they would keep their burners clean, we would hear less of it. This, we know, they will not do, and we have to accept the situation as we find it. We can give a much greater candle power with a mixed gas without smoking through the ordinary burners in use than with straight coal gas.

Right here let me say, I think the successful burner of the future will be more simple than the batswing or fishtail of the present day. If consumers will not take proper care of them, what may we expect of one that requires more attention.

In this day of electricity, we are compelled to give a much higher candle power than before its introduction. The eyes of the people have been educated to demand it, and we shall have to furnish it. This high candle power we cannot supply with straight coal gas. I do believe it would be much better for humanity, if we could not furnish a greater candle power than 16 candles. However, the oculist and optician must live and the people must give them a chance.

There has been a great deal said about the mixing of the two gases. Some insist it will stratify in the holder. This has not been our experience in Washington. Our gases are made and purified separately. After each kind of gas has passed its meter, they are worked into one main to the gas holder. I had an opportunity this summer of testing this question of stratification. We filled a holder, while painting it, and let it stand idle for two months. When turned on to the city it was worked quite low down before more gas was put into it. We could see no difference in the gas whatever. Another advantage in making a mixed gas is, you have a much wider field from which to select your material. If the coal men pinch you in price, you can go to the oil men, and vice versa. You can feel you are not dependent on any one material from which to make your gas.

One other advantage in a mixed gas is, you reduce very materially that component of water gas, which is considered by a great many as detrimental, namely, carbonic oxide. It is certainly a great advantage when your coke yard becomes overstocked and the price not satisfactory, you can turn it into water gas.

To come at the value of a mixed gas for heating purposes, I have made a few experiments to find its comparative value. The experiments were conducted as a consumer would use the gas. I used a double ring Bunsen burner, such as is ordinarily furnished with gas cooking stoves. I used a galvanized iron tank, of sufficient size to hold one cubic foot of water, six inches deep.

I found that with a coal gas, sp. gr. 431, candle power 14.60, burning at the rate of nine cubic feet per hour, air and water 68 deg., the first cubic foot of gas raised the water to 78 deg.; second to 86 deg.; third to 94 deg.; fourth to 102 deg.; fifth to 110 deg. The five cubic feet of gas raised the water 42 deg., or 8 4-10 deg. for each cubic foot of gas. The day following I made a similar test with coal gas, sp. gr. 445, candle power 16.12, air and water 68 deg. First cubic foot of gas raised the water to 76 deg.; second to 84 deg.; third to 92 deg.; fourth to 100 deg.; fifth to 108 deg. The five cubic feet of gas raised the water 40 deg., or 8 deg. to each cubic foot of gas. The ten tests of coal gas raised the water 82 deg., or 8 20-100 deg. to each cubic foot of gas.

I followed these tests with two of carbureted water gas. The first test, sp. gr. 584, candle power, 28.10, water and air 67 deg. First cubic foot of gas raised the water to 76 deg.; second to 85 deg.; third to 94 deg.; or 27 deg. for three cubic feet of gas consumed—burning at the rate of nine cubic feet per hour.

The second test was water gas (carbureted), sp. gr. 578, candle power, 27.62, air 68 deg., water 84 deg. First cubic foot raised the water to 93 deg.; second to 102 deg.; third to 111 deg., or 27 deg. for the three cubic feet of gas used. In the two tests, using six feet of gas, the water was raised 54 deg., or 9 deg. for each cubic foot of gas consumed.

The average candle power of the two tests of coal gas used was 15.36; that of the carbureted water gas was 27.86, a difference of 12.50 candles; and for this difference in candle power I gained 80-100 of one degree in heating power.

The first test of mixed gases, was of one-half each. Coal gas, sp. gr. 445, candle power 16.12, and carbureted water gas, sp. gr. 567, candle power 26.90. I first half-filled the holder with the lightest gas at the top, following with the heaviest gas at the bottom. I was testing the gases on the photometer at the time I was filling the holder; so it required fifteen minutes to fill each half of the

holder. I allowed the holder to remain idle for three hours, when I took the candle power and heating tests. The average candle power put into the holder was 21.51. The heaviest gas that went into the holder at the bottom as 26.90 candle power, came out 23.29. The last of the gas at the top of the holder came out 20.81. The average of the candle power that came out of the holder was 22.05, or 54-100 of a candle greater than went in. I made but two tests of the candle power of this holder; the first and last gas put in it. I desired to test the heating quality of the mixture, so I used the gas in the middle of the holder for this purpose.

As there had been, according to my test, an increase in candle power, I was not satisfied, but thought it was due to an error in my tests. I made another test three days later. The difference in this last test from the former one was, I put the heaviest gas into the holder first, filling it half full. This gas was sp. gr. 522, candle power 23.14, (carbureted water gas). I filled the remaining half of the holder with coal gas, sp. gr. 424, candle power 14.02. This made an average candle power of 18.58. After the holder had been idle for two hours I made the following test for candle power. The first test was 16.29, second 22.22, third 21.54, fourth 21.05, fifth 21.72. The five tests taken from the holder showed an average candle power of 20.56, a difference coming out of the holder, to what went in, of 1.98 candles. This has confirmed me in the belief that mixing one-half each coal and water gas increased the candle power.

In making tests of the heating power of the mixed gas, I found they varied but very little from the value of each gas combined. For each cubic foot of gas consumed the same as the former tests, I found it raised the temperature of one cubic foot of water about 9 deg. Some tests gave 9 14-100°, others gave but 8 deg. I find it varied as the mixture of gas.

I made one test of water gas not carbureted. I used the same burner, but of course had to exclude the air (as we use it with carbureted gas). I burned it at the rate of 15 cubic feet per hour. During the test the air was 64 deg., water gas 65 deg., sp. gr. 485. First cubic foot of gas raised the water to 69 deg., second to 73 deg., third to 78 deg., fourth to 82 deg., fifth to 86 deg., sixth to 90 deg., seventh to 94 deg., eighth to 98 deg., ninth to 102 deg., tenth to 106 deg., or 4 1-10 deg. to each cubic foot of gas consumed. Thus, uncarbureted water gas as to heating value, is but one-half that of illuminating gas. This water gas sold as a fuel gas, to do the same amount of work, will require a plant of double the size of that of illuminating gas. When it is sold at 40 cents per thousand, illuminating gas is as cheap at 80 cents, and in consequence of its odor is much safer about the house.

As this question of mixed gas is being looked into by a great many, I feel it is a matter that may interest us all. I hope others who are more able than myself may keep it before the gas associations. I do think that the most satisfactory gas of the future will be sixty per cent. of coal gas, to forty per cent. of water gas.

The President—The hour for adjournment has arrived, and it will be neccessary to postpone the discussion of Mr. Lansden's paper until the afternoon session.

The Association here took a recess until 2 o'clock P. M.

SECOND DAY—AFTERNOON SESSION.

The Association met at 2 P. M.

Discussion on Mr. Lansden's Paper.

The President—We will now take up the discussion on Mr. Lansden's paper on the "Advantages of Supplying a Mixture of Coal and Water Gas."

Mr. Robert Young—I would like to ask Mr. Lansden whether he made any change in the burner when he was burning 16 candle and 29 candle gas, The same burner is not suitable for both gases, and one is very apt to be led astray and to think that the 16 candle gas has about as high heating power as the 27 candle. I think the burner was at fault.

Mr. Lansden—I used the same burner.

Mr. A. C. Humphreys—I would like to say a word on the subject of stratification. To my mind it would be covered in this way, that if you give the gases a chance to mix they will mix completely. I think the idea that gases will stratify is entirely erroneous, but if you give gases a proper chance they will thoroughly mix. It will not do to say, on the other hand, that gases will not stratify in the ordinary acceptation of the term, because if you do not give them a chance to mix they will come out stratified to the consumer, but if you give them a chance to mix in the holder the mixture will go complete to the consumer. As to another point with regard to the mixture of gases by means of an exhauster, I would like to point out that of course it is not necessary to have any elaborate system of double purification after mixing. We could of course bring those gases together by the use of only one exhauster, and still mix in any required quantity of water gas with coal gas or *vice versa*, by the use of one exhauster and one holder. We are constantly doing that.

The President—Would there be any special objection, provided the two gases were of equal candle power, if they were not thoroughly mixed?

Mr. A. C. Humphreys—Yes; there would be. The same burner would not be adapted to the two gases, and you get unequal results. The gases ought to be mixed.

Mr. Robert Young—I quite agree with Mr. Lansden about the effect of using mixed gas. We use in Allegheny (where we have both processes) a water gas plant and a coal gas plant, and of course are mixing our gases all the time. The mixture of water gas to coal gas ranges from 25 to 75 per cent. Ours is not a water gas exactly but a mixture of 66.66 per cent. of water gas and 33.34 per cent. of natural gas—in summer we make 75 per cent. of this mixture and 25 per cent. of coal gas and in winter it is just reversed; taking the whole year we make 50 per cent. of each. As far as the stratifying of the gas is concerned we have no trouble with that. I also agree with Mr. Lansden that we make a better gas and a gas that is more satisfactory to the people than we did when we made a 16-candle coal gas. Our mixture of the whole gas averages from 18.56 to 19 candle power. Since we have been using water gas we have never had a single complaint from the people of smoked ceilings. Before that we tried to increase our illuminating power by injecting oil into the retorts, but if we thus increased the illuminating power to 18 or 20 candles the next thing we heard was about it discoloring the wall and ceilings. Since we have used the water gas, mixing it with the coal gas, we have never had a bit of trouble.

Mr. Cowdery—I have tried the same experiment that Mr. Lansden speaks of, and found the results to be very close to what he has stated.

On motion of Mr. Walton Clark, the thanks of the Association were voted to Mr. Lansden for his paper.

The President—We will next listen to the reading of the paper by Prof. E. G. Love on

GAS CALORIMETRY.

Prof. Love—Perhaps I should state, before commencing my paper, that the reason why there are no copies printed is due to my ignorance of the custom of the Association—a praiseworthy one—of having the papers printed in time to put them in the hands of the members at the meeting. I was not aware of that custom, and consequently did not send my paper to the Secretary in time to have it printed.

The constantly increasing demand on the part of the public for some cheap and efficient gaseous fuel naturally renders this one of the most important questions which engage the attention of a body of gas engineers.

The number and scope of the papers on gaseous fuel which from time to time have been brought before this Association render anything I might say from a strictly engineer's standpoint quite unnecessary. And yet as the efficiency of a gaseous fuel is quite as important as its cheapness, it has occurred to me that perhaps a few words on the practical determination of the heating power of gas might not be without some interest to the Association.

The object of calorimetry is to measure the quantity of heat which is produced or absorbed during any chemical or physical change; and a calorimeter is an instrument employed in measuring this heat. This includes the determination of specific heat, latent heat, heat of combustion, etc., and, consequently, the form of calorimeter must depend upon the nature of the investigation.

At present we have to do with the determination of the heat of combustion, and this is more especially as it relates to gaseous fuels.

The calorific power of a fuel may be defined as the total quantity of heat produced by the combustion of any given quantity of it. This power depends not only upon the chemical composition of the body, but also on certain chemical and physical properties. Thus

the calorific power of carbon in the form of wood-charcoal would be represented by the number 8,080, while in the form of the diamond it would be 7,770.

It is important to distinguish between *calorific power* and *calorific intensity*. The first has to do solely with the quantity of heat produced, and would be the same whether the combustion took place in oxygen gas or in the air. A piece of wood produces the same quantity of heat when allowed to decay in nature as when burned in a stove, but the calorific intensity is entirely different.

The calorific intensity, then, refers not to the quantity of heat, but to the temperature produced, and it is sometimes defined as the temperature to which the burning of any substance will heat the products of its own combustion. While the qua tity of heat is the same whether the fuel is burned in oxygen or in air, the calorific intensity of flame temperature would be very different. When burned in the necessary quantity of oxygen, the heat produced raises the temperature of the products of combustion only, but when burned in air the heat must raise the temperature of the nitrogen present in addition to that of the products of combustion, and consequently the temperature reached is not so high. When, as in practice, the air is, and must be in considerable excess, the flame temperature is even lower. As an illustration, a given weight of carbon when burned in the requisite amount of oxygen will give a temperature of 10,174 deg. C.; when burned with just enough air to furnish the necessary oxygen, the temperature is lowered to 2,715 deg. C.; and, lastly, when the amount of air is twice that necessary to furnish the oxygen, the temperature is only 1,408 deg. C. With hydrogen these figures would be . deg. C., 2,741 deg. C., and 1,550 deg. C.

In measuring calorific power reference is made to water as a standard, and a heat unit is the quantity of heat required to raise a given quantity of water 1 deg. in temperature.

Unfortunately some confusion exists from a lack of uniformity in the heat unit employed by different writers. In England and in this country the unit is either the pound Centigrade or the pound Fahrenheit. The pound Cent. unit is the quantity of heat required to raise the temperature of one pound of water 1 deg. C., while the pound Fahr. unit differs only in substituting the Fahr. degree for the Centigrade degree. Since 1 deg. on the Cent. scale is equal to $\frac{9}{5}$ deg. on the Fahr., the expression of calorific powers in the pound Cent. unit is converted into pound Fahr. unit by multiplying by $\frac{9}{5}$. The reverse calculation is made by multiplying by $\frac{5}{9}$.

The French unit, generally employed in France and Germany, is the quantity of heat required to raise the temperature of 1 kilogram of water 1 deg. C. It is called a calorie, and is equivalent to 2.2 pound Cent. units, or 3.96 pound Fahr. units.

The method of arriving at the heating power of any fuel by a calculation based upon certain generally accepted data may be relied upon in some cases, and yet, to a practical man, that method will naturally commend itself which determines the heating power by actual experiment.

For solid and liquid fuels a calculation gives only rough approximations to the truth, and this must continue to be the case so long as our knowledge of the constitution of the carbon and hydrogen in these fuels remains in its present imperfect state. To calculate the heating power of a sample of coal from the amount of carbon and hydrogen it contained, and the calorific values usually assigned to these elements, would be assuming that the carbon of the coal had the same heating power that it has in wood charcoal, and that the hydrogen had the same value as experiment has shown it to have in its elementary, gaseous condition. Some improvement is made when we recognize the probability, suggested by M. Cornut, that the fixed and volatile carbon have different calorific powers; and still we are very much in the dark.

With liquid fuels the data upon which to base a calculation of their calorific powers is as uncertain as with solid fuels.

In the case of gaseous fuels a calculation becomes more reliable since there is less uncertainty in the data upon which it is based. Two methods have been employed for calculating the calorific power of a gaseous fuel. The first considers the gas as containing known quantities of carbon and hydrogen, and its calorific power is calculated on the assumption that these constituents have the same calorific value as though in their elementary condition. This is open to the same objection noticed in the case of solid and liquid fuels; and the result based upon it is, therefore, erroneous.

The other method considers the gas as a mixture of hydrogen, marsh gas, olefiant gas, carbonic oxide, etc., for each of which a calorific value has been experimentally determined. If the percentage by weight of each of these constituents be multiplied into its calorific power, the sum of the products thus obtained will equal the calorific power per pound of gas. This gives us the most reliable result which it is possible to obtain by calculation. It involves a complete analysis of the gas in question, and, moreover, the nature and amounts of what are usually designated as "illuminants" or heavy hydro-carbons must be ascertained, since the constituents of the illuminants have different calorific values; thus it is that an actual laboratory test, while it may not be fully realized in the practical use of a gaseous fuel, is at once a more expeditious and satisfactory method of reaching the desired result.

In order to illustrate more in detail the methods employed in determining the heating power of gas I have sketched here three calorimeters suitable for such determinations. The first is that of Andrews (see Fig I.) which involves the explosion of the gaseous

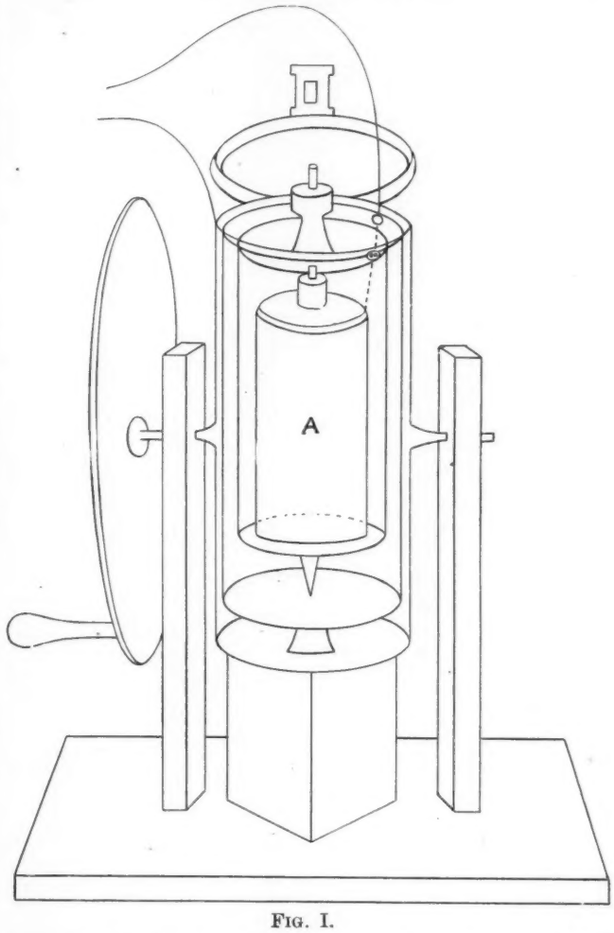


FIG. I.

mixture in a closed copper vessel. It consists of four cylinders, one within another. The gas to be examined, mixed with the requisite amount of oxygen, is inclosed in the vessel A, which is placed in a larger vessel filled with water. This is itself placed in a cylinder provided with a cover, and the whole inclosed in an outer vessel arranged to rotate on a horizontal axis. The apparatus is first rotated to establish uniformity of temperature, this temperature being then measured by a delicate thermometer. By means of the wires shown, a current of electricity is passed through a fine platinum wire, placed in the gaseous mixture, until the wire becomes sufficiently heated to explode the gas. The calorimeter is then closed and rotated for 35 seconds to distribute the heat through the apparatus. The thermometer is again introduced and the increase of temperature observed. This, together with the known calorific capacity of the apparatus, furnishes the necessary data for calculating the calorific power of the gas.

The second calorimeter is that of Favre and Silbermann (see Fig II.) It is so arranged that the fuel can be burned in oxygen gas. It consists of the combustion chamber A, made of gilt copper plate. Surrounding this is the vessel C C C, which is filled with the

water to be heated. Outside of c c is the vessel of silvered copper *b*, the space between this and c being filled with swan's-down. The whole is contained in the vessel *c c* to the bottom of which *b* is firmly fastened. The annular space between *b* and *c* is filled with water, the temperature of which is indicated by the thermometer *t*, and which serves to neutralize any accidental variations in the temperature of the atmosphere. The tube *d* serves to convey the purified oxygen into the calorimeter, and when the substance to be tested is a gas it is introduced by the tube *o*. The gaseous products of combustion escape by the tube *s*, pass through the coil s, where they communicate their heat to the surrounding water, and finally leave the instrument by the upper part of *s*. *a a* is a mechanical agitator,

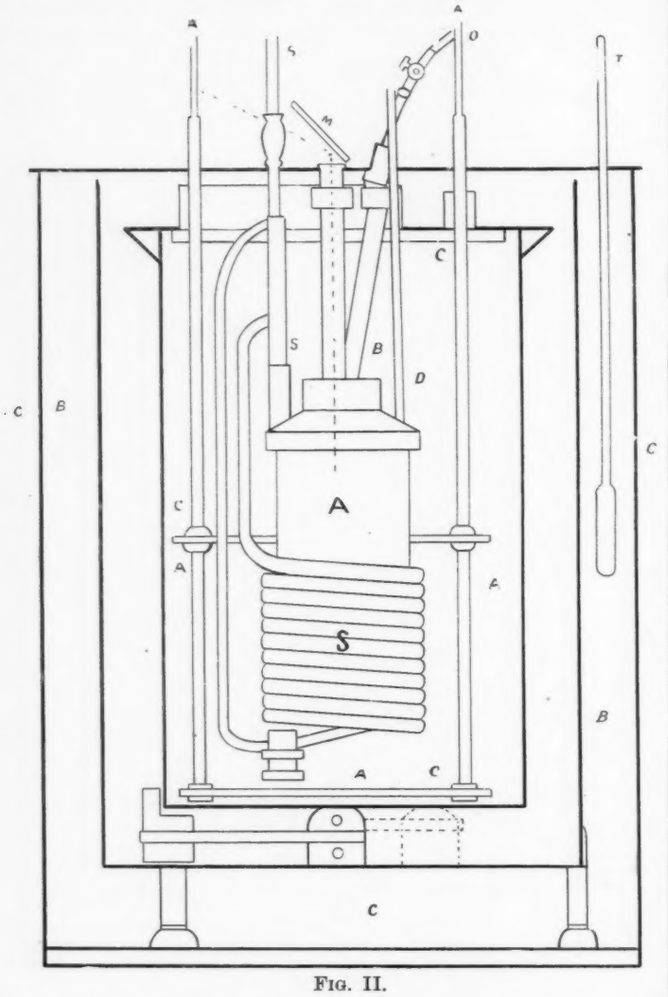


FIG. II.

and *m* a mirror which enables the operator to observe the progress of the combustion, the opening into the calorimeter being closed by a triple disc of glass, alum and quartz. In all cases where it was practicable Favre and Silbermann calculated the quantity of substance burned from the weight of the products of combustion.

The calorimeter to which I wish especially to call your attention is one devised by the late Mr. F. W. Hartley (See Fig. III.) It consists of the water cistern, A, provided with a ball-cock, and connected with a larger cistern or supply; B, the outlet of the cistern, is a glass tube containing a thermometer for ascertaining the temperature of the inlet water; C, is a water-jacket surrounding the Bunsen burner; D, is the body or calorimeter proper, consisting of a modified Coffey's still, which presents internally a large wetted surface for the absorption of heat; E, is a box to contain an anemometer when desired; F, is a copper chimney, and G is a ring-burner for heating the upper part of the chimney—this is necessary, inasmuch as the products of combustion, being below the temperature of the air, cannot produce the necessary draught; M, is the meter delivering 1-20 cubic foot of gas per revolution, and R, is a sensitive governor placed on the outlet of the meter. Delicate thermometers are employed to determine the temperatures of the atmosphere, the inlet water, the outlet water, the body of the calorimeter, the products of combustion, and the gas tested.

In working, the gas passes from the cistern, through the tube, B, and the jacket, C, to the upper part of the body, D, through which it descends, finding an exit through the lip into the collecting cistern, J. The gas is burned at the rate somewhat less than 1¼ cubic feet per hour, while the quantity burned in each test is ¼ cubic foot. With our gases of higher candle power I find that the consumption cannot much exceed 1 foot per hour, the experiment lasting about fifteen minutes. The gas and water supplies are first regulated so that the increase of temperature shall be from about 5 to 8 deg. Fahr., the water meantime running to waste. After this adjustment is

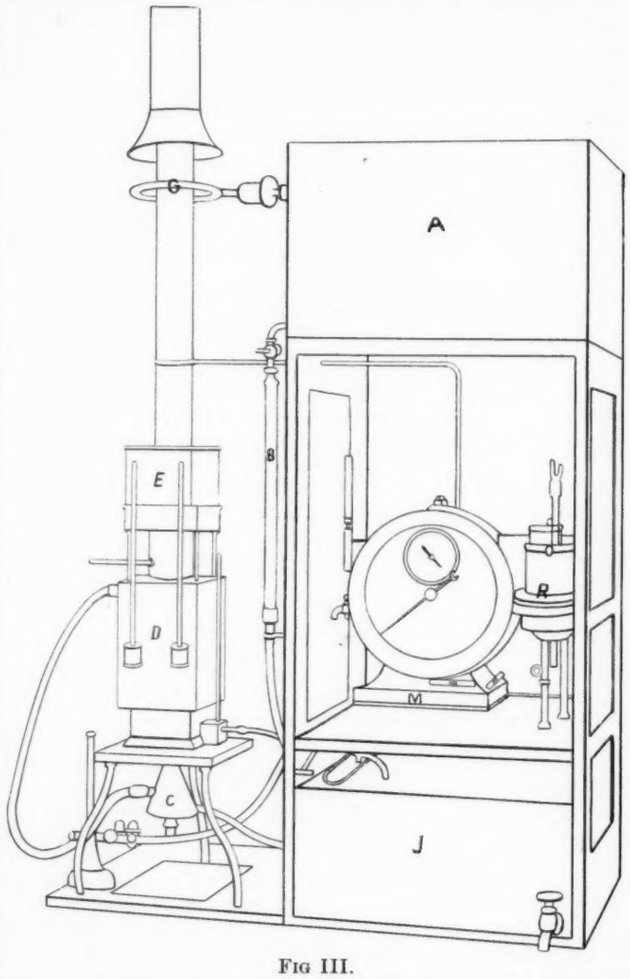


FIG III.

made and the readings of the thermometer are tolerably uniform, the index of the meter is taken and the outlet water turned into the collecting cistern. During the test the thermometer indicating the temperature of the heated water should be read frequently. My practice is to read this thermometer four times during each revolution of the meter, making 20 readings during the test. Each of the other thermometers is read five times in regular intervals. When the .25 cubic foot of gas has been consumed the water is turned to "waste," the time is noted and the water in the collecting cistern either weighed or measured and the weight calculated. The weight of water in pounds multiplied by the increase in temperature of the water and divided by the corrected volume of gas burned, gives the calorific power per foot of gas. The results obtained with any calorimeter require some correction, the nature and extent of which vary with the different forms of instruments. This is usually determined once for all. Mr. Hartley pointed out the following possible sources of error in his calorimeter.

1. Absorption of heat by the *body* of the instrument, and loss of heat by the heated water *receiver*. Experiments have shown that for each degree Fahr. which the body of the calorimeter is below the temperature of the air, it absorbs an amount of heat equal to .025 of a unit per minute, and that for each degree which the receiver—and issuing water—is above the temperature of the air it loses .01 of a unit per minute. If, therefore, an experiment lasted ten minutes and the body was 5 deg. Fahr. lower than, and

the receiver 5 deg. Fahr. above the temperature of the air, the corrections would be:

.025x5x10=1.25 gain, to be subtracted.
.010x5x10= .50 loss, to be added.

.75 unit gain, to be subtracted from the result for ¼ foot consumption.

2. Absorption of heat from the air supplied to the burner, and aspirated through the apparatus. From various tests Hartley became satisfied that not more than 13 feet or, say, one pound of air, passes for each foot of gas burned. On this basis, if the effluent gases were 3 deg. Fahr. below the air the correction per cubic foot of gas units would be .2379 (specific heat of air; Regnault) multiplied by 3=0.7137 unit. No correction is made for this small error.

3. Differences in the specific heat of water at different temperatures.

Regnault found the specific heat of water
at 86 deg. Fahr. . . 1.0020
at 50 deg. Fahr. . . 1.0005

0.0015, or 15 units in 1000;

equal to .04 of a unit in 1000 for each degree between 50 deg. and 86 deg. If 620 units of heat were realized per cubic foot of gas with water at any temperature between 50 deg. and 86 deg., the correction would be 620x.04—1000=0.025 of a unit to add.

No correction is made for this.

4. Radiation downwards from the burner. The burner is of the Bunsen type and radiation is not great. Moreover, the flame is wholly within the body, and any radiated heat for the most part falls upon the water-jacket placed around the burner tube. The loss, therefore, by radiation is practically nothing.

As to the efficiency of this instrument, I have not tested it as yet with any simple gas of known calorific power, but I may state that a test with hydrogen by Mr. Hartley gave 329.28 heat units per cubic foot at 60 deg. Fahr. and 30 in. This is equivalent to 62080 heat units per pound.

APPENDIX.

Memoranda of Calorific Test of Gas.

Temperature of air	69.28 deg. F.
" " water-inlet, below air	3.767 deg.
" " " outlet, above air	4.413 deg.
" " " raised . .	8.180 deg.
" " escaping gas . .	68.00 deg.
" " body	67.852 deg.
" " gas	69.00 deg.
Duration of test	15.033 M.
Gas burned	0.25 cu. ft.
" " corrected to 60 deg. and 30 in.	.24515 ft.
Lbs. of water heated	20.814

Correction:

1.428x.0258x15.033=.554 gain.
4.413x.01 x15.033=.663 loss.

.109 unit loss.

20.814x8.18=170.25+.11=170.36 ÷ .24515=694.92 heat units at 60 deg. and 30 in.

Candle power 21.94.

Table of the Calorific Powers of Gases, based on the Results of PROF. JULIUS THOMSEN.

GAS.	Formula	Specific Gravity Air-1.	Weight of 1 cu. ft. Grains.	Number of cu. ft. in 1 lb.	Calorific Powers. Lb. Fah. Units. Water—Liquid. Per lb.	Water—Liquid. Cu. ft.	Water—Vapor. Per lb.	Water—Vapor. Cu. ft.
Hydrogen.....	H	0.0693	37.04	188.98	61524.0	325.5	51804.0	274.1
Methane or Marsh Gas	C H4	0 5576	298.03	23.49	24022.0	1022.8	21592.0	919.3
Ethane.....	C2 H6	1.0374	554.48	12.62	22399.8	1774.3	20455.8	1620.3
Propane.....	C3 H8	1.5246	8 4.89	8.59	21825.0	2540.7	20057.7	2335.0
Ethylene	C2 H4	0.9784	522.95	13.38	21522.8	1607.9	20134.3	1504.2
Propylene.....	C3 H6	1.4980	800.67	8.74	21222.8	2427.5	19834.2	2268.7
Acetylene.....	C2 H2	0.9100	486 39	14.39	21492.7	1493.4	20745.0	1441.4
Benzine Vapor.	C6 H6	2.7000	1443.14	4.85	18183.4	3748.7	17435.7	3594.6
Carbonic Oxide	C O	0.9677	517.23	13.53	4395.2	324.7	4395.2	324.7

I have calculated the weight of 1 cubic foot of air at 60° F. and 30 in. pressure as 534.495 grains.

Discussion.

The President—This is a very interesting paper, and I have no doubt that the Professor will be glad to answer any questions you may ask him.

Mr. Jones—I would like to ask if it is true that the calorific power of carbonic oxide, when burned with oxygen, is greater than that of hydrogen when burned with oxygen, foot for foot.

Prof. Love—It makes no difference, so far as calorific power is concerned, whether the gas is burned in oxygen or in air. The quantity of heat is the same, but the temperature would be different. I have calculated the calorific power of hydrogen as 325.5 heat units per cubic foot, and that of carbonic oxide as 324.7 units. These figures suppose the aqueous vapor produced in the burning of hydrogen to have been condensed, and its latent heat rendered sensible.

Mr. Norris—Then the comparison between carbonic oxide and hydrogen is affected by the condensation of the watery vapor, and also by the temperature at which the gases are discharged. I believe that carbonic oxide takes about 2½ times as much oxygen to burn it as hydrogen, and, therefore, if you discharge the products of combustion at 600 deg. you lose more carbonic oxide than you do of hydrogen.

Prof. Love—No. These figures are based upon the supposition that the gaseous products are deprived of their heat. Of course it is important in any calculation of this sort to do that, or the figures would be quite different. In the case of hydrogen you have steam produced which goes off as vapor, carrying with it all the latent heat. These calculations are based upon the supposition that the aqueous vapor is condensed, and that the latent heat becomes sensible and is measured. When the vapor is not condensed, the calorific powers become 274.1 units for hydrogen and 324.7 units for carbonic oxide.

Mr. Norris—I meant marsh gas and not carbonic oxide.

Mr. John Young—I would like to ask to Prof. Love in what way he obtains the results when he is testing different gases. For instance, light carbureted hydrogen would require a much larger quantity of air for combustion than would hydrogen.

Prof. Love—The burner employed is so constructed as to allow an adjustment of the air supply to the gas burned.

Mr. John Young—Would there not be a liability to error on account of imperfect combustion?

Prof. Love—I think not, and still if the combustion were imperfect an error would of course be introduced. In order to insure against this the products of combustion should be examined. A glass tube can be inserted into the escape pipe, and the products of combustion drawn off and analyzed. If the analysis showed that the carbon had been burned to carbonic acid, and that no carbonic oxide were present we should conclude that the combustion had been perfect. It may be safely assumed that the same proportions of the gas and air would produce perfect combustion under practically the same conditions.

Mr. Nettleton—Before leaving Prof. Love's paper I would like to ask him a question. He has tested both water and coal gas; but I would like to ask him if he has ever tested a mixture or combination of water and coal gas; and, if so, if he has found that the result is the average candle power of the two gases—the theoretical candle power—or, if it is higher, how he explains that fact. Probably he is in a better position to make that test than any one else in the room.

Prof. Love—I have not made a sufficient number of tests on that particular point to answer your question. I may say that at my laboratories it is now impossible for me to get any pure coal gas, for the reason that, since the consolidation, it is mixed with water gas, and the only way is to bring the gas to my laboratory, or take my calorimeter to the gas works. At the Manhattan works they make pure coal gas, but in distribution it is mixed with water gas, so that I can never tell exactly what I am getting. I have determined the calorific power of that mixture, which contains about 50 per cent. of water gas. Of the water gas I have determined the heating power a great many times, but not of pure coal gas.

Mr. Nettleton—My question is as to the candle power. If you take coal gas of 18 candle power and water gas at 20 candle power, theoretically, the mixture should be 19 candle power; but, practically, it is stated to be above 19. Has Prof. Love found it so in his experience?

Prof. Love—I misunderstood your question. I have not made that test and cannot say how it would be.

Mr. Norris—How would it be with regard to the quantity of air?

Prof. Love—The latent heat would become a factor in the case of marsh gas and hydrogen, but not in the gas of carbonic oxide.

Mr. Glasgow—In the Favre and Silbermann instrument does it discharge the products of combustion at a temperature lower than the surrounding atmosphere?

Prof. Love—No; they cannot be lower than the temperature of the water, which is practically the temperature of the air, and corrections have to be made for every calorimeter.

On motion of Mr. A. C. Humphreys, the thanks of the Association were voted to Prof. Love for his valuable paper.

REPORT OF COMMITTEE ON NEXT PLACE OF MEETING.

Mr. Boardman—Your Committee has considered the place for the next meeting, and from the complexion of the Committee it seems to us that it would be very desirable to have the Association make a trip to the sunny South. We have thought that many of our beautiful cities would like to entertain us, but we have at last come to the unanimous conclusion that Savannah, Georgia, would be the best place at which to hold the next meeting (applause). In addition to the well-known hospitality of the South, we had the pleasure of receiving the following communications, which in a measure determined the exact location:

"*To the Committee on the Selection of a Place for the Next Meeting:*

"Gentlemen: Learning that your Committee is thinking of selecting some Southern city for the next convention of our Association, I wish to extend to the Association, in the name of the United Gas Improvement Company, a hearty welcome to any city in the South where our Company is in control of the gas interest. I would especially mention Atlanta, Savannah and St. Augustine.

Very respectfully yours,
ALEXANDER C. HUMPHREYS,
For the United Gas Improvement Co."

In selecting this place we wish to extend our thanks, and I am sure also the thanks of the Association, for the hearty welcome extended by the United Gas Improvement Company.

On motion of Mr. Denniston the report of the Committee was received, and the selection of the place for holding the next meeting of the Association, approved.

COMMITTEE OF ARRANGEMENTS.

The President appointed as a Committee of Arrangements for the next annual meeting: Alexander C. Humphreys, Philadelphia, Pa.; A. E. Boardman, Macon, Ga.; Thomas Turner, Charleston, S. C.; David Douglas, Atlanta, Ga.; W. G. Abel, Atlanta, Ga.

The President: The next paper read will be that by Mr. Frederick H. Shelton, on

ILLUMINATING WATER GAS—PAST AND PRESENT.

Mr. President and Members of the American Gas Light Association:

In presenting for your consideration a paper upon water gas—a subject that has probably excited more discussion and more controversy than any other one topic in the gas industry—it is, perhaps, well for me, at the outset, to briefly give my reasons for so doing.

To my mind, the present time marks a well defined and well rounded out period in water gas history, Known as a gas in the chemist's labratory a hundred years ago; struggling through the early stages of experiment; striven after by gas men and inventors throughout the century; frowned upon as illegitimate and with many an effort to throttle it by the older gas interests, water gas, like a lusty child, has steadily grown to be a stout, fighting competitor of, even threatening to outstrip, these older forms of gas manufacture, and has developed into a well-recognized and legitimate position in the gas industry.

Innumerable patents and methods for its manufacture have appeared, risen to a brief zenith of fame, and disappeared, until, as in the survival of the fittest, a well defined and commercially successful system of manufacture has been evolved. In this process of evolution, water gas has spread throughout the land, far more than I think most of us appreciate—and it is my intention in this paper to show you somewhat the extent of this growth, especially within the last 15 years; and, also, to give you a brief review of the early state of the art, together with a resume, of the practical methods for its manufacture to-day.

The Earlier History of Water Gas.—It is most interesting to note that the discovery of water gas, as a gas, dates back to a time when the composition and nature of gases in general was but little known. Hydrogen was known as "inflammable air," and when (in 1784) Cavendish made the discovery that it was one of the componerts of water, it was looked upon with great astonishment. Four years before this, however, one Fontana had called attention to the reaction which takes place between steam and incandescent carbon, at high temperatures, which, as you all know, is the basis of the whole theory and chemistry of water gas.

In "King's Treatise on Coal Gas" we find that Lavoisier and Meusnier, prominent chemists of that day, in investigating the composition of water, by analysis, "passed steam through a red hot pipe, whereby they obtained a quantity of 'inflammable air' which, when mixed with atmospheric air, or oxygen, exploded upon being ignited. They afterwards introduced charcoal in the pipe, which resulted in a considerable increase in the quantity of the gas, although of a somewhat different nature. This, then, was the first production of water gas." This period was practically contemporaneous with the earliest utilization of coal gas; for about 1793—eight years later—we find Wm. Murdoch, the universally acknowledged "father of gas lighting," "distilling the vapors from bituminous coals," and applying them to the lighting of his house.

The first one who appears to have attempted to apply Fontana's observations, and the theory of water gas, to practical gas making, was one Ibbetson who, in 1824, in England, made a water gas by passing steam through a mass of incandescent carbon. From this date down to, say, 1858, inventions succeeded one another in great rapidity—no less than sixty patents appearing within this period, all aiming to take advantage of the reaction of steam and carbon at high temperatures. In theory, water gas was recognized, and its desirability admitted, but in practice, in all this period, no commercially successful system of manufacture was hit upon. I will not tire you with a detailed list of these patents, for most of them failed to get beyond the patent office. Those who are interested can find them listed in the AMERICAN GAS LIGHT JOURNAL for September 16, 1864.

Some few of these patents are worthy of note, however, from the fact that they contain some one or two of the essential features of the modern water gas apparatus; and it was precisely the combination of these individual features that has produced the successful systems of to-day. For instance, in 1831, George Lowe patented a simple generator, for the express purpose of utilizing the hot coke drawn from retorts. The combustion of the coke was obtained by natural draft, instead of the modern forced blast; when a proper heat was obtained steam was admitted, decomposed, led off, and afterwards carbureted. Except in the matter of draft, mark the similarity to the modern Tessie du Motay system.

In 1832, M. Jobard, of Brussels, erected plants for supplying Dijon, Strasburg and Antwerp, and part of Paris, with "water gas impregnated with hydrocarbon vapors."

In 1839, George Cruikshank makes water gas in vertical retorts filled with carbon, and fired externally, a forerunner of the modern Allen-Harris type.

In 1847, Stephen White devised a somewhat similar apparatus, which met for a time with some little success, plants being erected at Ruthin, Southport, Warminster, Dunkeld, etc., and exciting some little comment in English gas circles. A good description of his method may be found in "Hughes on Coal Gas," edition of 1853.

In 1852, the Kirkham Bros. designed a furnace, or generator, to be "blown up" continuously, with the admission of a steam jet. The producer gas so formed was afterwards carbureted; and in this we have the forerunner of the modern McKenzie method.

In 1856, the system of M. Gilliard appears. This was simply the injecting of steam in a retort containing incandescent carbon, and the pure hydrogen gas, thus formed was used for light, through the medium of a platinum burner, heated to incandescence; the forerunner, again, of the modern, incandescent gas lighting systems. Extensive works of this type were erected at Narbonne and Passy, France, a description of which can be found in the AMERICAN GAS LIGHT JOURNAL for October 15th, 1860.

In 1856, also, Frederick Siemens invents the regenerative furnace, or the chamber filled with loose fire brick, for the storing up of heat from waste gases, which has since become so essential a feature of metallurgical furnaces, and which, under the name of superheater, and used as a fixing chamber, plays so important a part in most of the modern successful water gas apparatus.

Most of the patents up to this date were in England and France, and it is not until 1858 that we find record of water gas plants of any note, erected in America.

Just at this point—as we take up the list of water gas processes that have since appeared in America—I would call your attention to an important distinction, which I would have you bear in mind, viz.: the two general classes into which all water gas apparatus can be divided.

Class I, Retort Processes, or "those in which steam is admitted into retorts containing carbon, the temperature of which is maintained by combustion *external* to the retorts;" and

Class II, Generator Processes, or "those in which steam is admitted into retorts or furnaces (generators) containing carbon which has been previously heated by partial combustion of its own mass, or by *internal* combustion."

I would here state that in enumerating the various processes and apparatus, both in this class and the succeeding, I do not propose to attempt to list all of the several hundred water gas patents that have been taken out, but simply to give a *resume*, as far as I am able, of the forms of apparatus of which plants have actually been erected, and put to practical use.

We have in Class 1, Retort Processes:

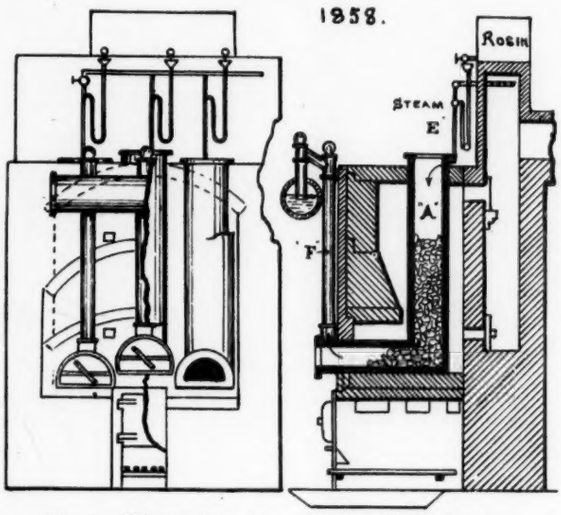
1st. The Sanders apparatus.
2d. The (Gwynne, or) Allen-Harris apparatus.
3d. The Salisbury (or Slade) apparatus.
4th. The Jerzmanowski ("Boot-leg," or Baby) apparatus.

The Sanders Apparatus:—In cut No. 1, I show a sketch of the first water gas plant of which I can find any record, as having been erected in the United States, and which illustrates the method of manufacture of Dr. J. Milton Sanders. In this, the "L" shaped cast iron retort "A," set in an ordinary bench furnace, was charged with charcoal and brought to a high heat. Super-heated steam was then admitted at the top at "E," and passing downwards, was decomposed and, uniting with the carbon from the charcoal, formed a non-luminous water gas. At the same time melted rosin was introduced in the retort for enriching, and the mixture passed out the standpipe "F," to hydraulic main, etc. You will see that there was almost no "fixing" of the gas, and this fact, together with the resulting condensation, and the excessive wear of cast iron retorts (owing to the high heats necessary for the decomposition of the steam), practically killed the system. It is interesting, however, to note the interest it excited. During the years 1859 and 1860, plants were erected in Philadelphia, at the Girard House; in Wilmington, Del.; Aurora, Ind.; Laconia, N. H., etc. Extravagant claims were made, and the columns of the AMERICAN GAS LIGHT JOURNAL at that period were filled with arguments respecting the merits of the apparatus. In fact, any one desiring a highly respectable water gas controversy need but go back thirty years, take this case in toto and change but the names and dates.

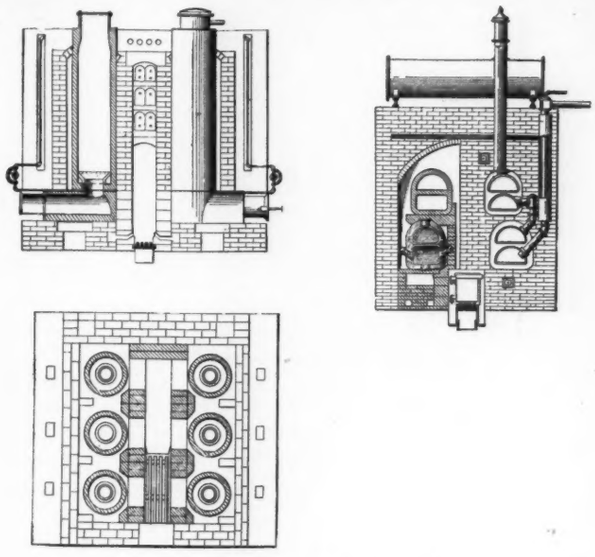
The Allen-Harris Apparatus:—The second method to excite general interest in gas circles was the "Gwynne-Harris," or American Hydrocarbon Process," as it was then frequently called. Mr. W. A. Gwynne, after taking out several patents, dating from 1863, and erecting a plant at Elizabeth, N. J., which was in operation for several years, became associated with Mr. G. W. Harris, also controlling several water gas patents, and together they erected at Fair Haven, near New Haven, Conn., in 1868, the first plant under the "Gwynne-Harris" system.

It excited much interest, was visited by many prominent gas men, and was the subject of five months' experiment and an exhaustive report of two hundred pages, by Professors Silliman and Wurtz, in 1869, which report was afterwards published, and can be found in the AMERICAN GAS LIGHT JOURNAL through the year 1874. Some time before this Mr. Gwynne died, and the "National Coal Gas Co." being formed, with Messrs. H. P. and A. L. Allen, at its head, the name gradually changed to "Allen-Harris," by which it has since been known.

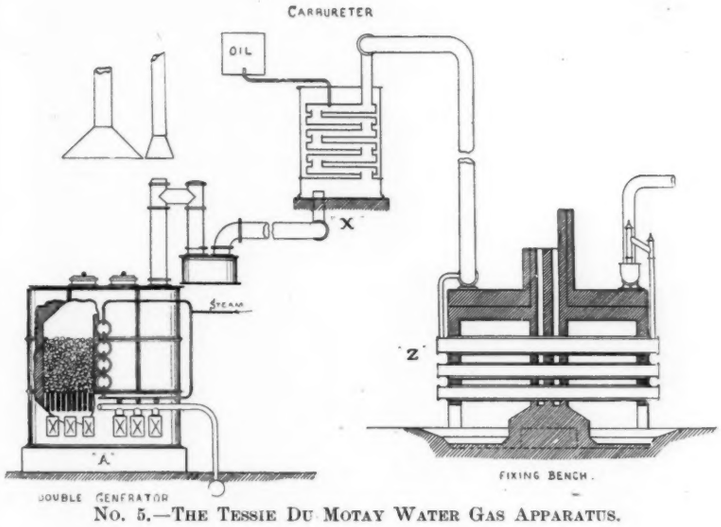
This system was almost the only one that occupied public attention in the Water Gas line from 1868 until the advent of the generator processes in 1875.



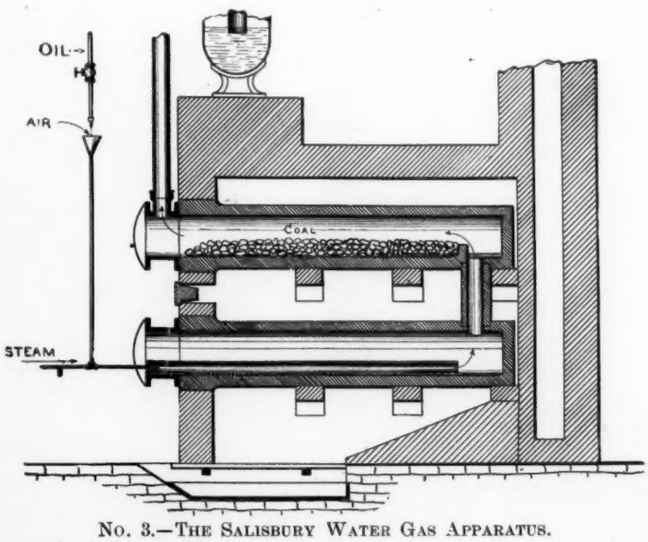
No. 1.—Water Gas Apparatus by J. M. Sanders.



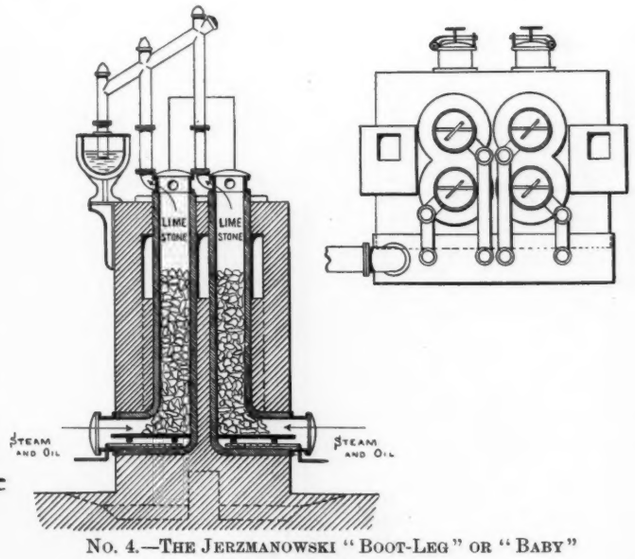
No. 2.—The Allen-Harris Apparatus.



No. 5.—The Tessie Du Motay Water Gas Apparatus.



No. 3.—The Salisbury Water Gas Apparatus.



No. 4.—The Jerzmanowski "Boot-Leg" or "Baby" Water Gas Apparatus.

Its backers stoutly took up the cudgels for water gas, writing column after column in its favor, and installed plants at Utica, Brooklyn and Westchester, N. Y.; Newark, N. J., etc., all of which were operated for a longer or shorter period.

Since that time, numerous patents for improvements have been taken out, and the apparatus introduced at Rondout and Poughkeepsie, N. Y. As one of the best developed of retort processes, it may be of interest to note cut No. 2, which shows the apparatus erected in 1884, at Poughkeepsie.

In this, "A" is a bench of vertical fire clay retorts. Each retort is filled with carbon, and steam, admitted at the top in finely divided jets, in passing down through, is decomposed; the gas so formed then passes to the bench of horizontal double retorts "B," "Oil C," for enriching, and the water gas "D" unite and pass into the lower chamber of the lower retort, and thence through 36 feet of increasing heats, to the standpipe.

The Salisbury Apparatus:—There have been numerous attempts by coal gas engineers to produce water gas in existing benches and retorts. These have resulted in many combinations of retorts, with the introduction of steam jets and hydrocarbon vapors, few of which have ever attained the dignity of a "process," or been heard of beyond the works of the inventor. It is manifestly impossible to herein describe all these efforts, and I will content myself with one, which is probably as typical and effective as any, and shown in cut No. 3.

The "Salisbury," or, perhaps, more properly speaking, the "Slade" method, as in operation at Yonkers, N. Y., for six years, consisted of the introduction of a jet of superheated steam, carrying a fine stream of naphtha through the mouthpiece of, and into a retort, in an ordinary bench setting. This stream of steam and oil vapor was then carried through a fire clay pipe on the bottom of the red hot retort to the rear end, where, issuing from the pipe, it expanded into the upper part of the retort, and passed forward and out of the standpipe. One or two retorts were used for the regular coal gas, to supply coke for firing the bench, and a later modification of the method was to pass the water gas from the lower retort up to and through the coal gas retort above. Although not so intended, as arranged at Yonkers, air was drawn in with the oil into retorts, resulting in a partial internal combustion, and adding a certain percentage of nitrogen to the gas.

The chief claims made for this method of manufacture were: Low cost of equipment; high candle power of gas; and the usual "general economy." It is worthy of note, however, that it has since been superseded by a much more typical and effective water gas apparatus.

The Jerzmanowski "Baby" Apparatus:—This form of apparatus, dating from 1886, consists of "L" shaped retorts (see cut No. 4), in the usual bench setting, the chief peculiarity of which is that the vertical portion of each retort is filled with "hard burned lime," or limestone, which is maintained at a red heat. Steam injected, as usual at the foot of the retort, and carrying a stream of naphtha is decomposed, and passing up through the lime "is converted or fixed into a permanent illuminating gas, by its contact with the hot lime in the upper part of the chamber." Other claims, also made, credit the lime with a peculiar but not satisfactorily explained action upon the gas, which results in "decreased purification," etc. To the untutored mind it would appear that the limestone simply acts as would fire brick, or "other refractory substances," to "fix" the gas. Plants of this form have been erected at Albany, Utica, Brooklyn and New York City, N. Y.; Boston, Mass., and several minor points.

These comprise all the retort methods of which I have any knowledge, for the manufacture of water gas. I am aware that sundry of what are known as "oil bench"—"processes," in which the oil is injected into retorts by a steam jet—claim to so manufacture a water gas. In the accepted sense of the term, however, this does not constitute a water gas process. I think that I have covered the recognized retort methods as above.

We now come to Class 2 or "Generator Processes." This class can be readily sub-divided into two divisions, viz.:

Section A.—Generator processes in which a non-luminous water gas is first made, which is afterwards carbureted; usually in a second apparatus, by the second fire, and in a second operation; and

Section B.—Generator processes, in which an illuminating water gas is made, carbureted and fixed entirely in one operation—one apparatus and with one fire; usually through the medium of a "superheater."

We have in Section A:

1st. The Tessie du Motay apparatus.
2nd. The Wilkinson apparatus.
3rd. The Jerzmanowski apparatus.
4th. The Hanlon & Johnson apparatus.
5th. The Edgerton apparatus.
6th. The Harkness apparatus.
7th. The Mackenzie apparatus.
8th. The Egner apparatus.
9th. The Meeze apparatus.

The Tessie du Motay Apparatus:—Pre eminently the most typical of its class is the Tessie du Motay form, which I illustrate in cut No. 5. "A" is the "gasogene," or simple generator, consisting of the usual fire-brick lined shell with coal bed, grate, air blast, and steam inlets, etc. In this, after attaining the proper heat, by "blowing up," the blast is stopped, and steam, admitted beneath grate, in passing up through the bed of incandescent coal, is decomposed, and the hydrogen gas thus formed passes to the "hydrogen holder." It then is brought to the carbureter "X," which consists of a series of shallow trays or pans of naphtha, heated to a vapor by steam in close contact.

The gas enriched by, and carrying thése naphtha vapors in suspension, passes to the retort "Z," in passing through which it is "roasted," or made into a fixed, permanent gas. It then goes to the purifiers, etc. You will note that in this apparatus, in blowing up the heat, the generator gases pass out the stack and up the chimney, and are absolutely lost.

The method above described, although named after the French chemist, Tessie du Motay, differs considerably from the original plan of working, as contemplated by him. This first plan covered the distribution of an "oxygen" gas, a plant for which was erected in New York, early in the seventies. This proved unsuccessful. Later, the system was again taken up, very materially modified, and brought to its present form, and in 1876 the first plant of any magnitude was erected for the Municipal Co., of New York, by the Continental Iron Works, of Brooklyn, N. Y., to whose energy much of the success of the system has been due. Other plants have since been erected at the New York, the Knickerbocker and the Harlem stations, New York city, and also at the Fulton-Municipal works, Brooklyn; Yonkers, N. Y.; Jacksonville, Fla., etc.

The Wilkinson Apparatus:—Closely resembling the preceding, but of somewhat later appearance and construction, is the Wilkinson apparatus—shown in cut No. 6—as constructed by Messrs. Bartlett, Hayward & Co., of Baltimore. From an authoritative description, I quote: "Steam is decomposed in the generators, and, after a scrubbing process, is carried to the hydrogen holder. From thence it passes through a station meter to the 'illuminator,' where it meets vapors of naphtha—produced by steam to a temperature of 240 to 260 deg. The mechanical mixture of water gas and naphtha vapors is carried to the benches in which the mixture is converted into a fixed gas. The benches are through benches of double the length of ordinary retorts; the mixture enters at one end and the gas issues at the other." From this you will see that the system is very similar to the preceding, and the claims of the one are practically the claims of the other, and are (aside from the general claims of economy, etc., common to every apparatus): 1st, that the make of gas is continuous; 2d, that an absolutely unform gas is produced, and 3d, that gas is produced at an absolutely uniform speed.

The first Wilkinson plant was erected, and is in operation upon a large scale, at the New York Mutual Co.'s works. Later plants are at Baltimore, Md.; Washington, D. C.; Buffalo and Rye, N. Y., etc.

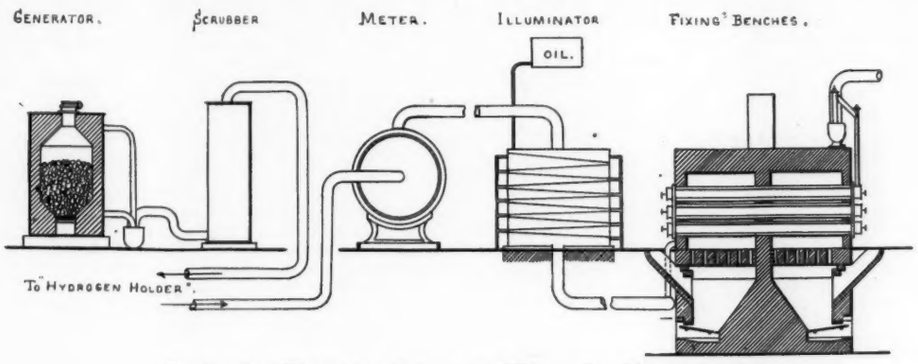
The Jerzmanowski Apparatus:—This apparatus, as erected at the "Equitable" works, New York, Chicago, Baltimore, etc., so strongly resembles the preceding, for the generation of the hydrogen gas, the latter carburetion, and the final fixing of the same, by passing through retorts, that a detailed description would be largely a repetition of what has gone before. The chief point of difference is in the generator. This, in addition to the chamber of incandescent coal, has a secondary chamber (see Cut No. 7), containing "hard burned lime," or limestone, which is heated by the products of combustion from the first chamber or generator proper. In making gas, steam, in passing through the coal, decomposes and meets, at the top of coal bed, hydrocarbon vapors; together they pass down through the limestone (which practically forms a superheating or *fixing* chamber), forming, perhaps, a 15 candle gas, which is afterwards enriched, as desired, to any degree and further fixed by carbureters and retorts, as previeusly described.

The Harkness Apparatus:—It is of interest to note in this connection, as indicating the difference between success and failure, a plant erected at New London, Conn., of the Harkness form, patented 1874, which, working upon almost the same lines as the preceding, yet, from the crudity of certain essential details and poor structural design, has amounted to nothing.

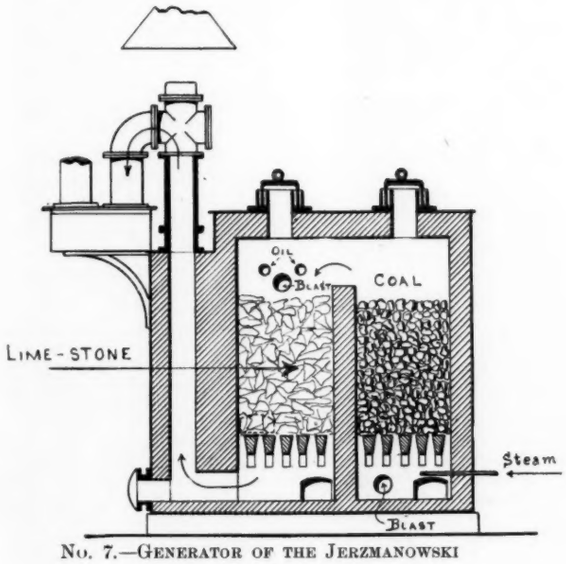
The method of manufacture, as in the preceding, consisted of the production of a non-luminous water gas in a generator (see cut No. 8), from which the gas was led off to retorts, carbureted with naphtha vapors, and "roasted" or made into a permanent fixed gas. The generator was small, difficult to fire, and to maintain proper combustion in; the coal was gotten to a proper heat by a slow draft, as compared with the modern blower or forced draft. This made an extremely slow production of gas, which in turn produced high labor account. To correct this, several generators were operated in conjunction. The gas went as made, regularly or irregularly, to the retorts—no hydrogen holder intervening. While this system had strong claims made for it at the time, as a matter of fact, it was short-lived. But one plant, as far as I know, was erected, and that has now been in disuse for some years.

The Hanlon and Johnson Apparatus:—In 1878, under the auspices of the "United Petroleum and Water Gas Co." appeared the system of manufacture known as the "Hanlon and Johnson," which attained some little success at the time, and which I illustrate in cut No. 9.

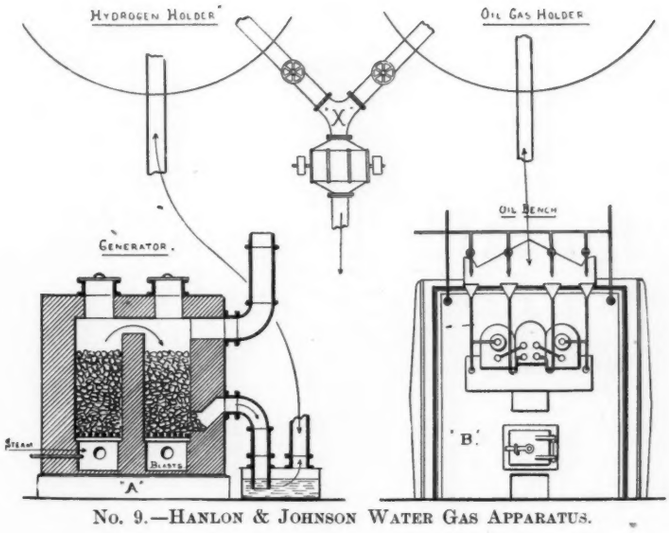
In this "A" is the usual plain generator for the production of non-luminous water gas, which is led off to one holder. "B" is a "Hanlon Bench," for the production of a pure oil gas, which is led off to another holder. An exhauster "X" draws gas from each holder, mixing in the pipes, and it is obvious that by the adjustment of valves the proportion of water gas and oil gas drawn from their respective holders and, therefore, the exact candle power desired can be maintained to a nicety. In theory this was excel-



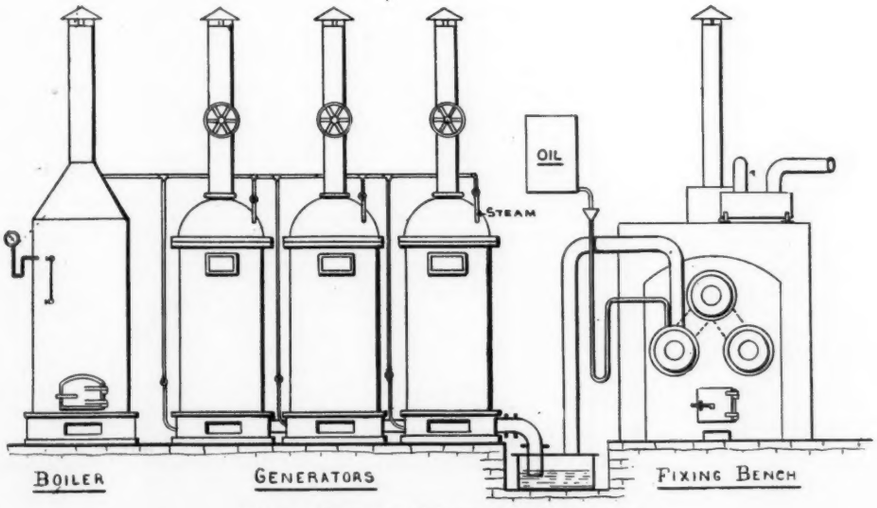
No. 6.—The Wilkinson System of Water Gas Manufacture.



No. 7.—Generator of the Jerzmanowski Water Gas Apparatus.



No. 9.—Hanlon & Johnson Water Gas Apparatus.



No. 8.—Harkness Water Gas Apparatus.

lent; in practice it was unsatisfactory and expensive. The gases having but a mechanical mixing, developed a strong tendency toward condensation, and had the lack of "stiffness" of flame peculiar to oil gases. The absolute lack of utilization also of the generator gases was a wasteful feature.

There is no better illustration of the advancement of the art of water gas manufacture from uneconomical to economical methods, than to state that in the cities where the "Hanlon & Johnson" apparatus was some ten years installed, viz.: Rochester, N. Y.; Reading, Penn.; Dover, N. H.; San Francisco, Cal.; Atlantic City, N. J.; and several other points, almost without exception, these plants have since been superseded by more modern and more efficient water gas systems.

The Edgerton Apparatus.—A system very similar to the above, but, in at least one feature, a decided step in advance, is the Edgerton, which I show in cut No. 10.

In this "A A" are generators as before, for water gas; "B B" are vertical retorts for the production of oil gas. The improvement comes in from the fact that the generator gases, which in all the systems heretofore mentioned in the present class, are allowed to go to waste, are, in this apparatus, to a certain extent utilized, being used to fire the retorts which make the oil gas; a continuous supply of gas for this purpose being had by using two generators in conjunction. While one is making water gas the other is being "blown up," and vice versa. The water gas and oil gas after being separately made, are drawn by exhausters through meters and mixed in measured quantities, as in the preceding method—cold and mechanically—and passed on through the purifiers to the holder. A distinct feature of the Edgerton system was the distribution of a gas of very high candle power, selling it upon the basis of the amount of *light* received, with the use of a "dollars and cents" meter. Plants upon this system have been erected at Danbury and Wallingford, Conn.; Pensacola, Fla.; New Orleans, La., etc.

The Mackenzie Apparatus:—Still another form of apparatus, using a generator separately, and afterwards carbureting the gas, is the Mackenzie, which is of interest as showing an attempt to get a continuous production of gas with the use of a generator, but with the usual result, viz.: the gas is loaded with nitrogen, which is its own condemnation.

In the Mackenzie method, which I show in cut No. 11, the generator fire is blown up continuously. At the same time a steam jet is also continuously admitted, and the resultant "producer" gas is led off to a bench of ordinary retorts, and carbureted by passing through same, with naphtha added. Sufficient coal gas is made in one or two retorts to produce coke for firing the bench, which coal gas is mixed with the water gas at the hydraulic main. While a number of these plants were erected some years ago, they have all, as far as I know, fallen into disuse—the nitrogen in the gas probably being a chief factor. The last one, to my knowledge, now in operation, is just being supplanted by a later water gas process.

The Egner Apparatus:—The apparatus of Frederic Egner, of 1887, shown in cut No. 12, is very similar in operation to the preceding, and illustrates another effort to attain a continuous manufacture, with the use of a generator. "A" is the generator for making "producer" gas, "B" is a "carbureter" seal, through which the gas, in plunging, is enriched by the oil or naphtha, which replaces the usual water for sealing. From it the gas is conducted to the "fixing" chamber, or retort, in passing through which the gas is made permanent, and thence passes to the hydraulic main, purifiers, etc. A plant of this form has been erected at the Laclede works, St. Louis, and one, also, I believe, at Waco, Texas.

The Meeze Apparatus:—The last form of apparatus of the class which we are now considering is that of A. G. Meeze, of England, patented 1886, and controlled by the "International Gas Co.," plants of which have been installed at New York, N. Y.; New Orleans, La., etc.

This apparatus (see cut No. 13) consists essentially of fire clay retorts in an ordinary setting. In the center of each retort is a 4 "ingression pipe" (leading almost to the rear end) which is filled with "bafflers," through which a jet of superheated steam and hydrocarbon vapors is injected. These vapors, after going through the "bafflers" and expanding from the "ingression pipe" into the body of the retort, pass through a second series of "baffle plates" to the front, to the standpipe "A" and hydraulic main. The rich oil gas thus formed is afterwards reduced by a mixture of water gas, made by any generator method, which water gas may be admitted in the retort, hydraulic main or other point.

I think you must have already noticed the main feature—I might say the main fault—of this class of apparatus just described, viz.: that in all these methods of manufacture to make a fixed illuminating gas, two operations are involved—first the *making* of a water gas and afterwards the *carbureting and fixing* it.

We now come to the consideration of a type of direct apparatus in which these two operations are combined in one. And in this class, in noting the various forms that have achieved commercial success, we find that no matter how much they differ in design, in proportion, in detail, or in construction, there is one great central feature common to all—a feature that has made the system a success, and which is the basis of their classification, as a process—and that feature is: the use of a superheater for storing up waste heat from the generator, by which to fix or make permanent the mixture of steam and oil gases.

In the second class—or Section B ("Generator Processes in which water gas is made, carbureted and fixed entirely in one operation, one apparatus, and one fire; usually through the medium of a superheater")—we have:

1st. The Lowe apparatus.
2d. The Granger apparatus.
3d. The Hanlon-Leadley apparatus.
4th. The Springer apparatus.
5th. The McKay-Critchlow apparatus.
6th. The Flannery apparatus.
7th. The Martin apparatus.
8th. The Pratt and Ryan apparatus.
9th. The Van Steenburg apparatus.
10th. The Loomis apparatus (early type for illuminating gas).

The Lowe Process and Apparatus:—The credit for the invention of the process (which is the basis of the class of apparatus we are now about to notice), whether considered chronologically, practically, or legally, belongs unquestionably to Prof. T. S. C. Lowe, of Norristown, Penn.

Identified with gas interests since the war of the rebellion, where as chief aeronaut of the army of the Potomac, he was engaged in the manufacture of gas for ballooning purposes, and later connected with the illuminating gas interests, in 1872 he took out a patent containing some of the features of and leading up to the patent of 1875, which is the base of the modern water gas system. This, as to time, is about the same period as the first Tessie du Motay plant in New York.

Devoid of technicalities, the Lowe process covers broadly the use, in connection with a generator, of a superheater or fixing chamber, fired by the combustion within it of the gases which are formed in "blowing up the heat" in the generator; also the introduction of oil, or other enriching substances, into the hydrogen gas and the fixing of the two by passage through the superheater into one permanent fixed gas. The process also covers the use of the superheater for superheating steam, if so desired, instead of for fixing the gas.

The first Lowe apparatus was erected in Phoenixville, in 1873; the next at Conshohocken, and the third at Columbia, Penn., all by the inventor himself.

Messrs. S. A. Stevens & Co. then took an agency (their first works being at Utica, N. Y.), and later organized the "American Gas, Fuel and Light Co." to whom a general license was given. About the same time Messrs. A. O. Granger & Co. commenced building this apparatus, closely followed by Messrs. Pierson Bros., and the "National Gas Co."

By these various parties, Lowe apparatus was erected at very many places throughout the country, until 1882, when the patent rights were acquired by the United Gas Improvement Co., of Philadelphia, who have since continued the erection of the apparatus.

I show two cuts of the Lowe apparatus. Cut No. 14 shows the earliest and original form. Cut No. 15 shows the latest construction. In general features, sequence of parts and operation, they are alike: "A," the generator, a fire-bricked lined chamber, contains anthracite coal, or coke, which is raised to a state of incandescence by an air blast, admitted beneath the grate. The products of combustion, or gases, formed in this operation pass out at the top through the "goose-neck" connection "C," to the base of the superheater "B," where, by the admission of a secondary air blast, they are burned, heating the fire brick with which the superheater is filled. When the proper heats are obtained, the blasts are shut off, stack valve closed, and steam admitted beneath the grate in generator "A." This passing up through the coal, and decomposing, forms a non-luminous water gas, and meets the oil vapors for enriching, which are admitted through pipes in the top of the generator. The oil and steam gases then pass through pipe "C" to superheater, where, by contact with the red hot fire brick, they are "fixed" into a permanent illuminating gas.

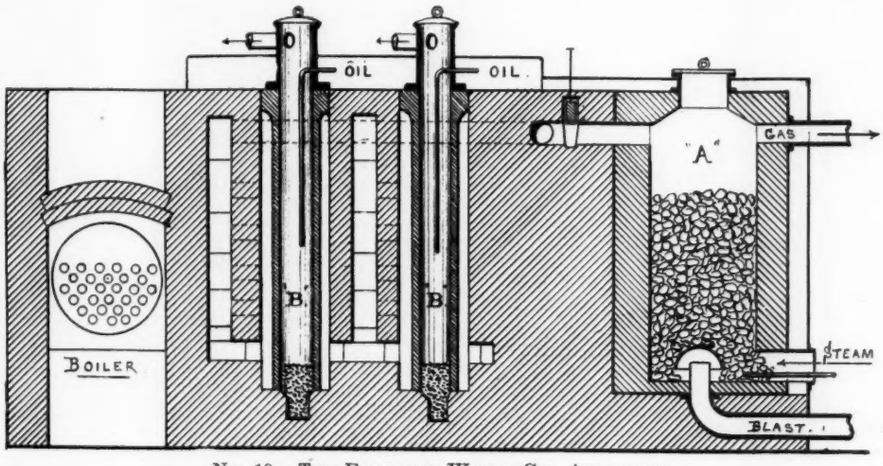
Cut No. 14 is of interest as showing the crude early construction of the apparatus, and the old form of hydraulic seal or "washer," with diaphragm, which, holding the gases under water, not only "washed" the gases, but frequently, also, washed out some portion of the illuminants. For which reason this form was speedily discarded.

Cut No. 15 shows the modern or "double superheater" construction—the chief changes (aside from the mechanical and detail work) being the increase in depth of the generator, and the enlargement of the old pipe connection "C" into an entire superheater.

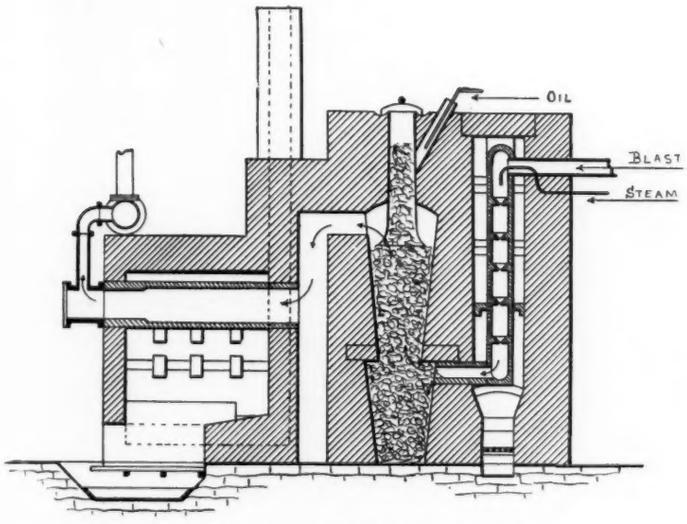
The filling brick in this first superheater, or "carbureter," as it is usually termed, from the fact of the hydrocarbons being often there admitted, is peculiarly arranged for the use of heavy oils. Ordinary checker bricks are used, but so laid up that continuous "core holes" are formed from top to bottom, which in the use of crude oils, allow the heavier impurities to drop entirely to the cleaning doors at base.

A highly efficient form of the double superheater type is that known as the "Humphrey's" setting, as erected at Chicago, Toledo, Terre Haute, etc. In this arrangement two complete sets of apparatus are connected by flue at the generators. Both sets of apparatus are "blown up" together. In gas making steam is admitted at the rear of one set, is superheated and carbureted in this set, and passing on to the second is finally gasified and "fixed." During the next run this course is reversed, steam being admitted in the opposite set. This setting is particularly adapted to large works.

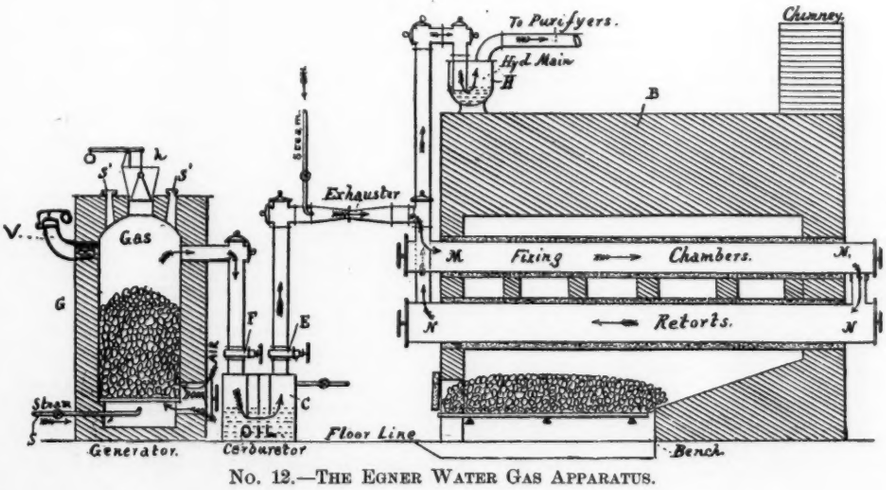
The claims for this form of apparatus, aside from the general ones of high economy, etc., are, first—by the great depth of generator, the ability to use coal or hard or soft (gas house) coke at pleasure; second, by the utilization of waste heat, for the highest



No. 10.—The Edgerton Water Gas Apparatus.



No. 11.—Mackenzie Water Gas Apparatus.



No. 12.—The Egner Water Gas Apparatus.

pre-heating of the oil, and by the use of two superheaters, maintained at different heats, the ability to use, to the best advantage, cheap crude oils, or distillates, etc., and, third, by the great superheating capacity, the ability to properly fix the gas at moderate heats; so doing away with the danger of lamp-black and naphthaline accompanying high heats, and the question of lack of fixing of the gas, present in some other forms of apparatus.

The Lowe apparatus, in various forms, has been erected all over the country. I will not here attempt to list the places; a glance at the chart behind me will show its record.

The Granger Apparatus:—The first of this class to make its appearance after the Lowe was the Granger apparatus, of which I show a typical setting in cut No. 16.

The firm of A. O. Granger & Co., dating from 1878, originally erected Lowe water gas apparatus, under license from S. A. Stevens & Co., then controlling the patents. In doing this many improvements in detail and in construction were made, and finally, patents were taken out for the "Granger" form, which you can readily see is an evolution from the Lowe. The two most essential differences were: 1st, the doing away with the old goose neck, heat-radiating connection ("C" in cut 14) by locating the generator in the cellar, with the shells slightly lapping, thus giving a short direct connection from shell to shell, and bringing all the operations of gas making upon one floor; and 2nd, the introduction of the oil, at a high temperature, in the form of a spray or vapor, at the base of the superheater; the claim being that in such a form it was much more readily taken up and gasified by the hot stream of water gas than as before when dropped upon the top of the coal bed of generator in a solid stream. Messrs. Granger & Co. went largely into the detail of parts and of construction, and by erecting a simple and effective plant, did much to popularize this type of water gas apparatus. Their efforts were highly successful, for up to 1885 they erected, chiefly in the middle and eastern States, over seventy sets of apparatus. One plant erected by this company at Chicago, with generator 13 feet in diameter, is interesting as indicating the limit of size to which a generator may be made. This plant in question, while turning out great quantities of gas, yet owing to the large mass of fire to be handled, and practical difficulties of construction and operation, was not entirely satisfactory, and precisely as experience has determined a practical limit in size for retorts, so were Messrs. Granger & Co. well convinced that the limit for size of generators had been exceeded.

In 1885, the Granger Water Gas Co., was consolidated with the United Gas Improvement Co., since which time this form of apparatus has been erected by the latter company.

The Springer Apparatus:—Closely following the preceding, as a practical and efficient apparatus, comes the "Springer" cupola system. This form of construction, under the patents of Mr. T. G. Springer, which were later transferred to the "National Gas Light and Fuel Co.," by whom the system is now controlled, has the chief distinctive features of a generator and superheater entirely in one shell; of certain new methods of introducing the oil and of certain modifications of the course of the gas through the apparatus; the advantages claimed being the minimum of radiation and the maximum of heat conserved for the superheater, together with suporior economies in general.

This single shell, or "cupola" form of apparatus, was also one of the several earlier forms of apparatus erected by Prof. Lowe, and has since been adopted by later constructors, as will be noted further on.

The first Springer plant was erected in Chicago, in 1882, since which time it has rapidly grown in favor, large plants having been erected in San Francisco, St. Paul, Minneapolis, Chicago, etc., and also in many smaller cities and towns, chiefly in the Western States, around the upper Mississipi.

Cut No. 17 illustrates this apparatus; "A" being the original form and "B" a modification of it. In this latter form, the generator is "blown up" in the usual way, the gases passing through the combustion pipe "L" around the solid arch "K" to the superheater.

In making gas, steam admitted at "M" (the pipe "L" being closed) passes down through the coal bed and up the external pipe "N," to top of superheater, where it meets the oils, which together pass down through the superheater, and out at "O." A still later modification of this construction permits the course of the steam and gas currents to be either up or down.

The Hanlon-Leadley Apparatus:—The first Hanlon-Leadley apparatus was erected at Passaic, N. J., in 1884, by the United Coal and Oil Gas Co. controlling the patents. Since then numerous plants have been erected at other points, viz.: Reading, New Haven, Chicago, Manchester, Philadelphia, etc. The apparatus, containing all the essential features of the Lowe, is chiefly distinguished by the use of two or three generators on a common communicating base. Perhaps the best illustration of which is the latest plant erected, known as the "W" setting, and which I show in cut No. 18. The three generators are all blown up to a proper heat together, part of the products of combustion being used to heat the small superheaters "B," the bulk of the gases, however, passing through the three pipes, "K" "K" "K," to heat the two superheaters "P" "P," also on a common base. When ready to make gas, the valves "O" "O" are closed. Steam is first admitted at the top of both small superheaters "B" "B," and passing down is superheated, and thence continuing down through the outside generators, the two streams meet at base of the center generator. They pass up through this generator and to this point their course has described the letter "W," whence the name of this setting. Oil is admitted at top of center generator, and the gases pass over through center pipe "K," to superheater, for fixing as usual. The usual claim for high economy is made, in this case being based largely upon the superheating of the steam, and of the operation of several generators together. From this latter it is obvious the apparatus is best adapted to works of a large size.

The Flannery Apparatus:—Another type of apparatus, and one that has been introduced at some of the principal gas works of the country, is that built under the patents and designs of Mr. Jos. Flannery, and which I illustrate in cut No. 19. In general appearance it differs from the usual series of cylindrical shells, in being built in a rectangular wrought shell, and in pairs; although the halves of these pairs are operated independently of one another. Internally, the chief difference is, as usual, in the handling of the oil. The generator "A" is fired, and hydrogen gas made in the usual manner. Upon leaving the generator the gas passes into a "D" shaped retort, located around three sides of the top of the superheater. In this retort the oil is admitted and vaporized, the water and oil gases traveling through it together around the shell, back to the starting point, where they descend the vertical flues "M" to base of superheater, to be fixed in the usual manner. This apparatus, first erected at Middletown, Penn., in 1881, has since been introduced upon a large scale in Boston, Chicago, Jersey City, New York, etc. Other plants have been erected in St. Jago, Cuba; Duluth, Minn.; Wlmington, Del., etc.

The McKay-Critchlow Apparatus.—In cut No. 20 I show a cut of what is commonly known as the McKay-Critchlow apparatus, although, strictly speaking, built under the patents of Peter English, of 1884. These patents were for a water gas generator in a single shell, having the sole distinctive feature, as shown by the cut, of a solid arch, separating the generator from the superheater, *around* which the gases pass, instead of the usual *perforated* arch *through* which the gases may pass. By reason of this "greatly improved results" were claimed; upon just what basis is beyond my comprehension.

The first plant of this form was erected in London, Ont., in 1882. About 1884 Messrs. McKay & Critchlow, holding patents for the carbureting of natural gas, by means of a cupola, formed with W. H. Denniston, the "American Gas Improvement Co." of Pittsburgh, which Company acquired the rights to the Peter English apparatus, and also the patents of Messrs. Robt. Young and J. H. McElroy, for the treatment of natural gas.

Although natural gas can undoubtedly be carbureted in very many different ways, yet I think I am right in saying that the most successful efforts, commercially speaking, have been under the above patents, with the use of a cupola, in which the gas simply replaces in part, the steam of an ordinary water gas process—passing through a generator and being decomposed by the coal, and afterwards being carbureted and fixed in a superheater. From this first use for natural gas the Peter English very readily drifted into use for a straight water gas apparatus, and we find many plants erected for either purpose among the small gas towns of New York, Pennsylvania and Ohio.

In 1888 the several patents above were acquired by the United Gas Improvement Co., by whom they are now controlled.

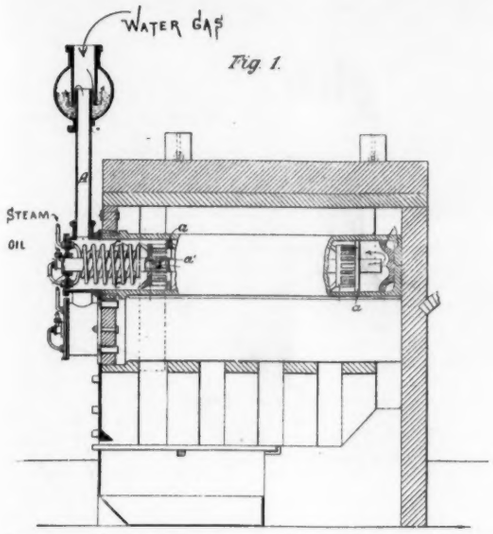
The Martin Apparatus:—In cut No. 21 I show you still another form of apparatus, known as the Martin. This is similar to other types in operation and sequence of parts, but differs, as usual, in the introduction of the oil.

In this apparatus the connecting flue from generator to superheater is broadly expanded, and has at its upper part "A," a tile or slab upon which the enriching naphtha is dropped from inlet pipes above. This oil is vaporized by the hot water gas and carried on to the superheater, where the two are "fixed" as usual.

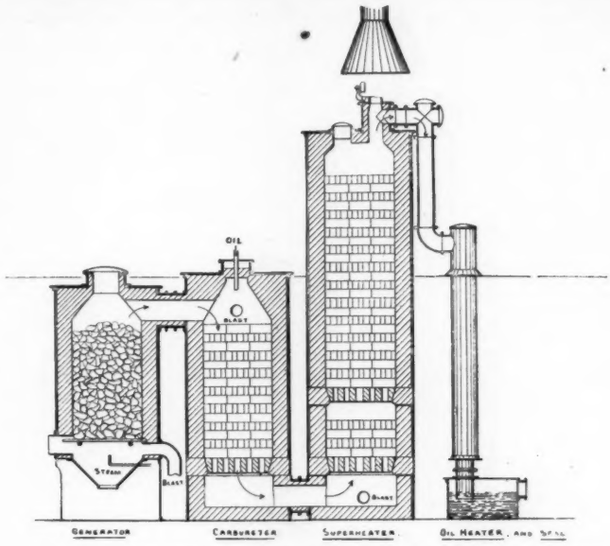
Plants of this description have been erected at St. Paul, Minn.; Newburgh, N. Y.; Washington, D. C.; Macon, Ga., etc.

The Pratt & Ryan Apparatus:—Still another form of the cupola, or single shell type, and the last that has appeared upon the commercial field, is the Pratt & Ryan apparatus, dating from 1887, which I show in cut No. 22. You will see at once that in general arrangement it is the same as some of the preceding forms, but differs somewhat in the filling of the superheater. In place of the usual checker brick is a series of fire brick arches; each of which also serves as an oil inlet, the arches being cored and perforated. The oil is admitted in the centre of each arch, radiates through each arm, and emerges into the chambers between each, where it is taken up by the flow of water gas; any particular arch is used at pleasure, according to the heat of the superheater. Several large cupola generators in Chicago have recently been remodeled to this construction, and smaller plants have been erected at Goshen, Ind.; Creston, Iowa, etc.

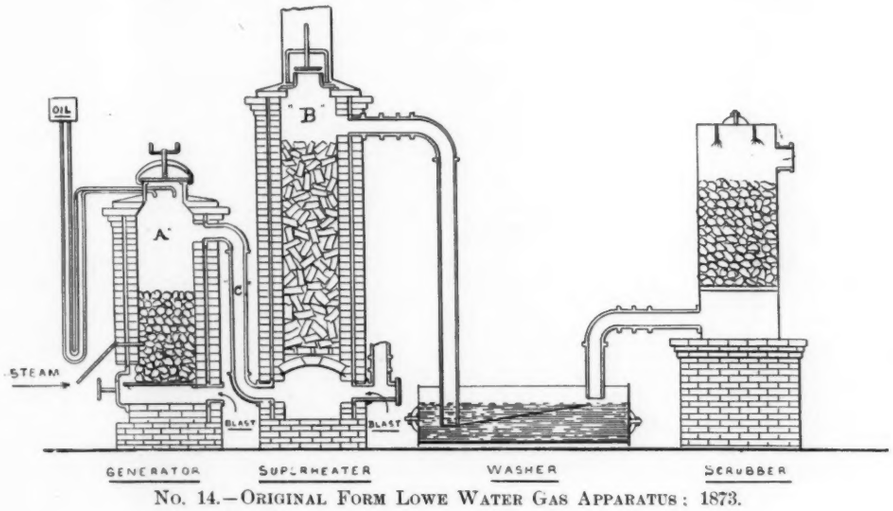
The Van Steenburg Apparatus:—The apparatus under the patents of B. Van Steenburg, 1881, which I illustrate in cut No. 23, may be taken as a fair example of numerous attempts (such as the Averill, Boeklen, etc.,) to make a compact generator-superheater all *in one chamber*. In this case it is accomplished by inserting fire-brick tile "D" in the top of the generator, to give superheating or "fixing" capacity. These tiles, while heated by the gases from the generator, do not begin to utilize all the heat therein—simply absorbing the sensible heat—no secondary air supply being given for combustion. From this very minimum superheating



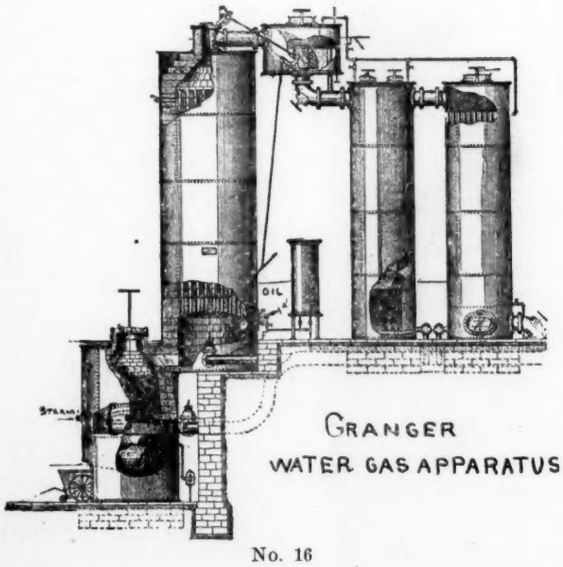
No. 13.—The Meeze Oil and Water Gas Apparatus.



No. 15.—Modern Form Lowe Water Gas Apparatus; 1889.



No. 14.—Original Form Lowe Water Gas Apparatus: 1873.



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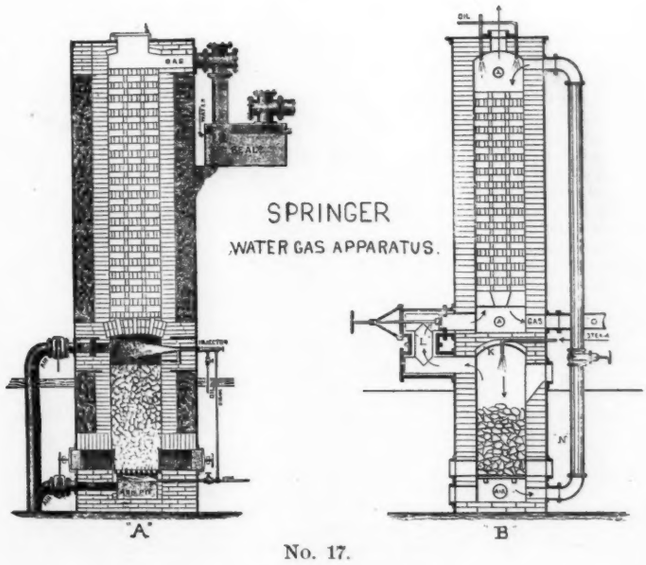


No. 17.

capacity, it is obvious that the apparatus is limited to a moderate make, and to the use of the lightest hydrocarbons (naphtha, etc.) to produce a gas at all fixed.

Several plants of this form were erected some years back, at Goshen, Herkimer, Amsterdam, etc., N. Y.

The Loomis Apparatus:—While the Loomis system has been mostly pushed upon the lines of a non-luminous fuel gas, there is one plant of this name erected at Cottage City, Mass., in 1884, that comes within the scope of the class we are now considering. This apparatus, which I show in cut No. 24, is of considerable interest, as illustrating an attempt to use soft coal in the regular generator-superheater process, and to that end, in the superheater, instead of having the usual checker brick work, we find a series of thin partition walls, for superheating surface—the idea being to allow no lodging place for ashes or soot that might accompany the use of soft coal. Any such deposit, falling entirely to the bottom of each vertical division, where are handholes for cleaning, etc. The generator also is somewhat different. the air blast passing *down* through the coal instead of up, as in the usual fashion. When a proper heat has been attained, steam is admitted in the generator, at the top, passes down through the coal, is decomposed, and meeting the oil for enriching in the intermediate chamber "B," passes on through the superheater, to washer, scrubbers, etc. While good success was claimed for this apparatus, it is a significant fact that, although the inventor has since erected numerous plants, he has not duplicated this style of works. These latter plants, however, have been more especially for the production of a non-luminous fuel gas, in generators only, any portion of which, if desired for illuminating purposes, is afterwards carbureted in retorts, in the manner of the preceding class.

The whole subject of fuel or non-luminous water gas, and the apparatus for its manufacture, not being within the scope of this paper, I shall not enter upon, but will leave to abler pens than mine, the description of the various apparatus and systems advocated by Messrs. Lowe, Strong, Evans, Rew, McMillin, Loomis, Humphreys, Clark, etc.

Now to what process have all these forms of apparatus which I have enumerated, dating back an hundred years, led up to, as the successful system of water gas manufactured to-day? Obviously, the answer to this is: That which has been most generally adopted. This then becomes not a matter of opinion but of statistics, and three lines will show it, viz.:—(Taken from the list of water gas plants appended.)

Number of retort process plants	9
Number of generator process plants, Section "A" . .	46
Number of generator process plants, Section "B" . .	312

Undoubtedly it is the last type—and the great feature of this type which has so far outstripped the others—*is—by the use of an internally fired superheater*, the getting of all the necessary operations of water gas making into one compact apparatus, which—costing the least for erection, operated with a minimum of labor, and above all, by the utilization of heat previously wasted, has made a direct saving of heat, of energy, and of dollars. The successful apparatus of to-day is built upon these lines; appearing in a dozen different forms, differing as is but natural, in design, proportion and efficiency, according to the various construction, but all having the great point in common—of the use of an internally fired superheater (the invention of which, by T. S. C. Lowe, has been so strongly upheld by the late decision of Judge Wallace) this type of apparatus has been erected throughout the country, and with the greatest success.

Many localities I can indicate where it is superseding older forms of water gas apparatus, which have now almost ceased to be erected, and so completely is the generator-superheater type the process of to-day, that while knowing of at least 25 new plants, of the same, erected this season, I can scarcely find enough of the others to count. It is not to be wondered at. Compare it for instance with the other type of this class, where the blowing up the coal in the generators to incandescence, an enormous amount of heat is lost up the chimney, and absolutely wasted (a criminal offence in these days of high efficiencies) and then a second fuel account is started to carburet and fix the gas. Is it any wonder that a system which (leaving out all other questions of labor, repairs, convenience, etc.) combines these two operations in one, has so rapidly distanced the others?

I do not mean any disparagement on the one hand, or praise upon the other, of any particular apparatus, but I do mean, in contrasting the several *types*, that the generator-superheater system, all-in-one-apparatus, is pre-eminently the choice of those adopting water gas to-day. I am not here to recount the old arguments for or against water gas, to rehearse the efforts of those interested, to stay its progress, or to condone the "serpentine" methods which were used, unfortunately, at times, by both sides. "We are confronted with a condition, not a theory," and that condition is, that water gas is to-day one of the largest and most prosperous branches of the gas industry. Fourteen years ago there was scarcely a plant in the country; to-day, over 300 cities and towns, or nearly thirty per cent. of all the gas towns in America, have over 350 distinct plants, and the output of water gas constitutes, probably, one-half of all the gas made in the United States. Since 1885, or within the last three years alone, water gas has doubled—in that year there being less than 150 cities using it.

Look at the map yonder and notice how water gas, indicated by the red dots, has spread throughout the country. From Maine to California, from Florida to Winnipeg—we find it everywhere. Look at New York, with fifty water gas towns; look at Pennsylvania; out of 108 gas towns over fifty per cent. are water gas, I do not mean "auxilliary" plants, but out and out water gas, only three of these points making coal gas. But you say, Pennsylvania is especially well adapted for water gas from nearness to the hard coal and oil fields. Look then upon Vermont—without a coal gas works in the State; upon Florida—where six out of nine gas points are water gas. Oil is the cheapest gas making material to transport to these distances. Look at Ohio, in the centre of the soft coal field. A few years ago there was scarcely a water gas plant in the State; to-day there are 20 and steadily increasing. In Massachusetts, with laws cleverly passed to prohibit it, a dozen plants are daily manufacturing it, and so on, from one end of the country to the other.

Now what is the cause of this wonderful growth to its present proportions? I answer, *the intrinsic worth of the system itself*. It must be so, or it would never have grown to its present position. The London *Journal of Gas Lighting* speaks of water gas as "Almost an ideal system." Certainly a method of manufacture, that occupies a minimum of floor space, uses a minimum of labor, and costs the minimum for repairs—a system of enormous capacity, that can be started into full operation at a few hours' notice, completely utilizing gas making materials of minimum bulk, having no residuals, and giving their highest candle powers, is *bound* to prosper. And when, in addition to the above, in a majority of cases, a direct reduced cost of gas in the holder, is added, a still more potent reason is seen for its adoption. Equally well is it adapted to the largest and the smallest works, for while the largest plants are in use in New York, Brooklyn, Boston, Philadelphia, Chicago, San Francisco, etc., and nearly every other large city, yet have I seen also a water gas plant of the smallest size, (in a town of 2,000 population, with no mills and but 1 1-2 miles of street mains), completely installed in an old church building, 30x50 feet. The generator in the Sunday-school room, the holder in the auditorium, the oil tank in the pulpit, and a pipe shop in the organ loft. Although this plant burned down without insurance, yet the owner immediately rebuilt, for even on as small a scale as this, there was money in it.

Much as water gas apparatus has been improved since its beginning, its capacity doubled, the quality of gas made vastly better, the ability gained to use crude oils, tars and distillates, with entire success, likewise coals and cokes heretofore deemed impracticable, and the far better mechanical construction of the apparatus, there is still ample field for the water gas engineer to work in Details of design and proportion that are by no means yet agreed upon, the utilization of the highest degree of the heat of the escaping gases, in the more perfect heating of the incoming oils, steam, blast, etc., the perfect shaking grate, and the absolute utilization of all kinds of fuel, are problems as much yet to be solved as those to which the coal gas engineer looks forward in striving to perfect his bench, or to utilize his residuals.

I believe that these problems will be solved, and in the near future; that soft, or bituminous coal—the cheapest fuel in nearly every locality—which in the past has been the mainstay of the gas maker, will so continue to be; but will be used direct and completely in a water gas apparatus, and enriched with some form of petroleum. Regarding the future supply of this desirable commodity, I am neither prophet nor oil expert; however, from the very many places of its discovery—Pennsylvania, Ohio, New York, Tennessee, Texas, Wyoming, Colorado, California, Canada, etc. (to say nothing of the fields as yet undiscovered), and the great fields of Russia (beside which our own pale into insignificance) which are but awaiting a pretext to utilize the 1,300,000 gallon tank steamers already built, to lay their products at our doors—I believe that we need have but little fear of the oil supply question.

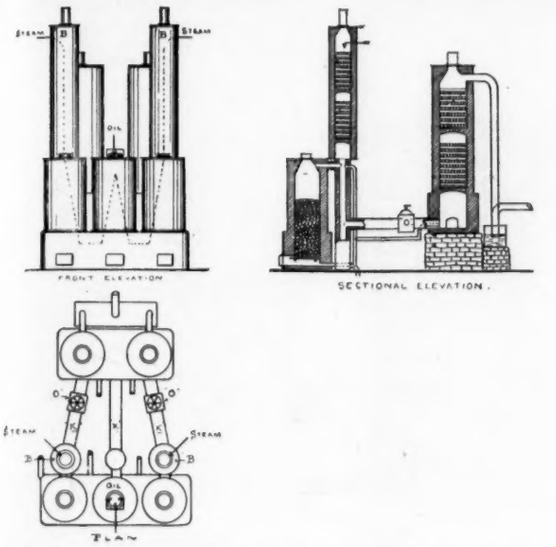
Until that millenium day of fuel gas, when, with mains and holders quadrupled, we shall be sending out unlimited quantities of an uncarbureted gas, or at least as long as we continue to make an illuminating gas. I agree with Dr. Walther Hempel, that "The water gas process is, without any doubt, one of the greatest inventions connected with the gas industry since gas was first made use of," and also believe, with the eminent chemist, Rudolph Wagner, that "water gas appears to be the illuminating gas of the future."

The subject is almost endless. My paper now is much beyond the length I contemplated, with many points but touched upon, and still more entirely omitted. I trust your patience has not been too severely tried.

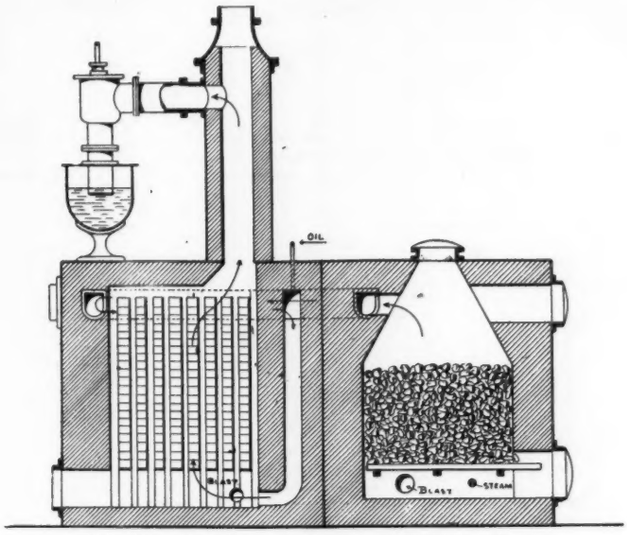
In closing I would call your attention to the list of water gas towns to date, attached to this paper, which I have prepared with some care, also to the list of reference papers consulted, which may be of use to the student; which papers form about the only, and largely unsatisfactory literature, upon the subject.

I also wish to herewith express thanks to numerous constructors of processes herein described, for their courteous replies to my request for information concerning the same, for this paper.

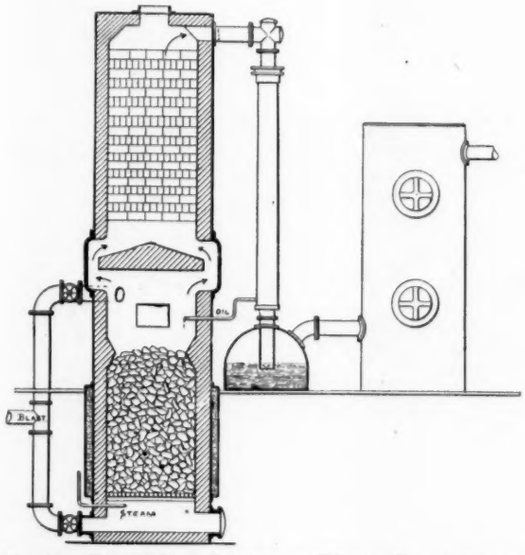
Mr. Shelton—Before the discussion is opened upon this paper I would like to call the attention of the Association to the charts which I have placed on the wall. The first I have referred to in my paper. I think you will find it interesting as showing the distribution of gas towns throughout the country. My object in preparing that chart was to show any one who thinks that water gas does not amount to much in North America, or who thinks that water gas is confined to local districts, or who thinks that water gas has not grown to any great extent, that he is laboring under a mistake. I respectfully invite any such person to count the red



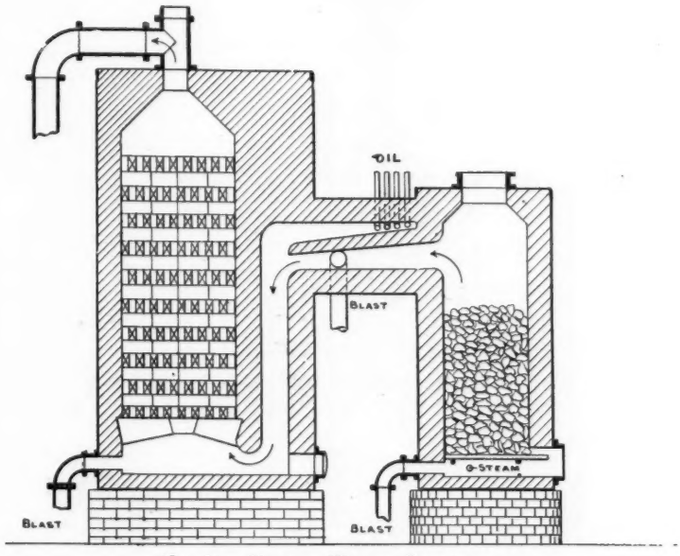
No. 18.—The Hanlon-Leadley Water Gas Apparatus.



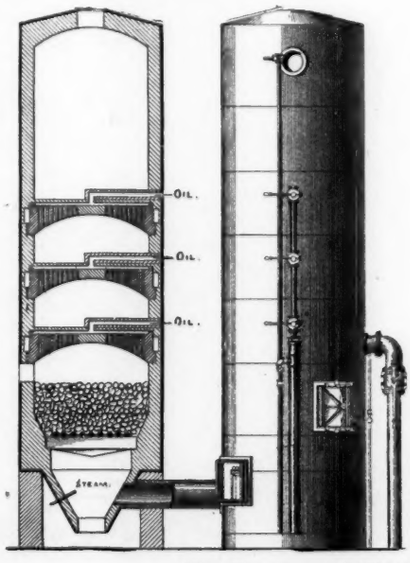
No. 19.—The Flannery Water Gas Apparatus.



No. 20.—The McKay-Critchlow Water Gas Apparatus.



No. 21.—Martin Water Gas Apparatus.



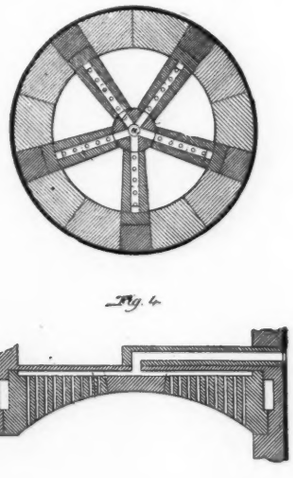
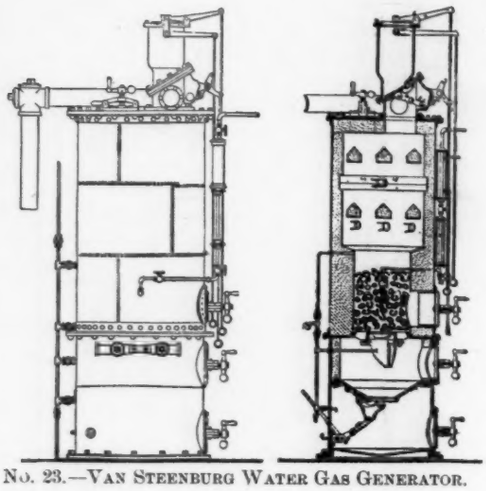
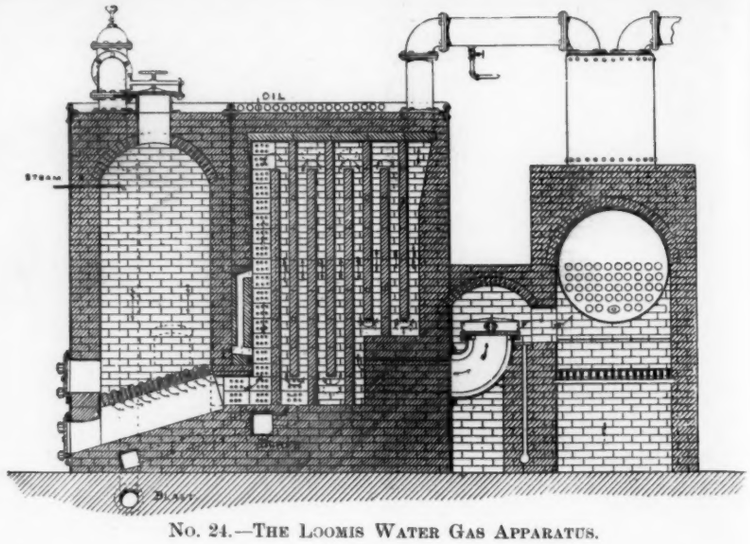


Fig. 4.

No. 22.—Pratt & Ryan Gas Generator.



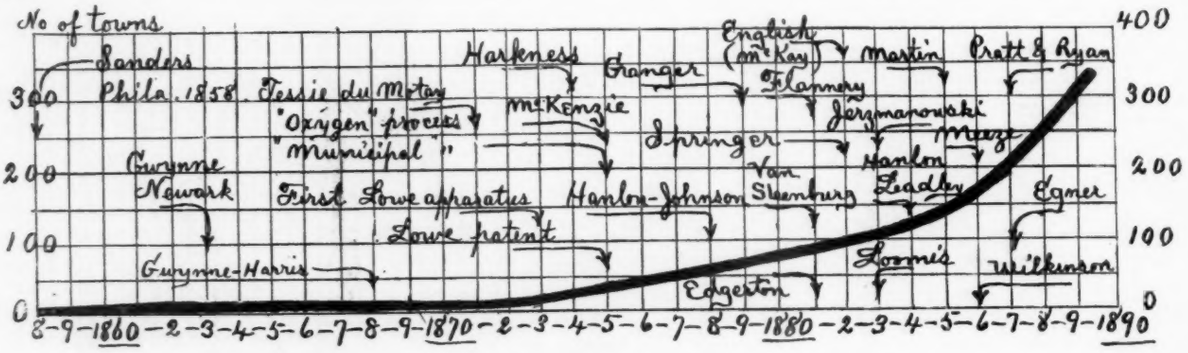
No. 23.—Van Steenburg Water Gas Generator.



No. 24.—The Loomis Water Gas Apparatus.

SOME WATER GAS STATISTICS.

Diagram showing the yearly growth of Water Gas by number of towns adopting same, and the chronological appearance of the leading forms of apparatus.



Total number of gas towns in America (about)	1100
" " that have adopted water gas	305
" " water gas plants erected	367

These Plants, as to special "process" or form of apparatus, sub-divided as per proportional table below, viz:—

Lowe	120
Granger	49
Springer	45
McKay-Cricthlow	39
Flannery	12
Hanlon-Leadley	13
Hanlon-Johnson	9
Martin	4
Pratt & Ryan	5
Evans	2
Van Steenburgh	8
Loomis	8
Allen-Harris	3
Edgerton	5
Egner	2
Jerzmanowski	10
Strong	1
Salisbury	1
Meeze	2
Wilkinson	6
Tessie du Motay	5
Mackenzie	4
Harkness	1
Rose	1
Rew	1
"Home-made"	3
Unknown plants listed as water gas	8
Total	367

These 367 plants sub-divided as to GENERAL SYSTEM OF MANUFACTURE show "Retort processes" 9

Generator processes, Section "A," such as the Tessie du Motay, etc., method 46

Generator processes, Section "B," or those based upon the LOWE generator-superheater principle 312

337

9
46
312

367

spots on that chart. The red spots indicate companies which have adopted water gas wholly or in part; and the green spots represent all the coal, or wood gas, or whatever you please. The data is taken from "Brown's Gas Light Directory," which is about the only source of authority we have in such matters, coupled with information which I have already obtained. In this chart I call your attention to a little diagram which indicates the growth of water gas, by years. Each one of those spaces, from one side of the sheet to the other, represent one year. You will see that in 1858 the first water gas appeared—that of Sanders; and two or three plants were erected about that time. We find none others until 1863. Then there is one at Newark; and in 1868 we find the first plant under the Gwynne-Harris system. In 1873 the Lowe patent appears and from that date the Lowe plants were erected. Each one of these spaces indicate 50 companies. We will see from that date to the present time that there are over 300 companies formed within fourteen years, and that during the last three years alone the number has gone from 150 to 300, thus duplicating itself within three years. The proportional table given below indicates the number of plants which have been erected. The third line here indicates the substance of my paper, which is this: That the superheater apparatus is the apparatus for to-day. That is shown by statistics and indicated graphically by these three lines at the bottom. On such a subject as this it is very difficult to get absolutely correct information, and I presume one or two mistakes are made in the list of water gas companies; but I think that it is correct as a whole, and I believe that the percentage of error will be found inside of one per cent.

Discussion.

The President—The paper of Mr. Shelton is a very comprehensive presentation of the progress and present condition of water gas in this country. I hope gentlemen wishing to ask any question, or who have any remarks to make will now do so.

Mr. Scriver—I presume that the cost of oil differs in different localities the same as coal.

Mr. Shelton—Undoubtedly.

Mr. Scriver—The price must certainly enter into the question. The company that I represent manufactures coal gas entirely, and by comparison with the Toronto Gas Company, which manufactures part coal and part oil gas, we find our results to be more satisfactory than those at Toronto, in figures of dollars and cents.

Mr. Shelton—That is a question that one would have to go into very fully, and take all the points into consideration, before arriving at a definite conclusion.

Mr. Scriver—In discussing the cost of coal gas you have to take into consideration the sale of your residuals; and that is how we beat the Toronto Company. We get a very good price for our coke, and for our other residuals—coal tar and ammoniacal liquor. So that, taking into consideration the prices we get for our residuals, we beat oil gas all to pieces.

Mr. Shelton—Of course it is a question of dollars and cents. If a company is so situated as to get coal cheaply, and can obtain high prices for residuals, coal gas may be less expensive than water gas; but in a majority of places I think it is not so.

Mr. Pearson—I did not catch what Mr. Scriver said. He alluded to Toronto, and I understood him to say that coal gas beat water gas all to pieces. I heard that much, and that he was making a cheaper gas in Montreal than we are in Toronto. I do not wish to enter into any personal discussion, and I will merely say that Mr. Scriver can get his coal at Montreal for about half the price that we can buy our coal in Toronto. That is a very important consideration. I will say to Mr. Scriver that we have been making about half and half coal and water gas with our old coal gas works. I do not know how Mr. Scriver arrived at his figures, or at the cost of his gas. I do not know that I give him any data by which he can come to a conclusion; but I may say this, that we have been making gas by the old Lowe gas process in Toronto, and that we contemplate making a change. I am quite aware that we might make gas a good deal cheaper by that process; but I do not know exactly how he makes out that his gas is cheaper; and I would like at some future time to have a little talk with him in private. I do not accept that, however, on his mere statement.

Mr. Scriver—Mr. Pearson's memory must be very short; I wish that I had the reports that we figured upon at the time that we proved to Mr. Pearson that we were getting very much better results from coal gas than he was getting from water gas. I wish also that I had Mr. Pearson's letter that I might read it to you. If Mr. Pearson would like a copy of it I can send it to him after I get home; but I have no doubt if he refers to his letter book he will find there a copy of the original. What I have stated is entirely correct, although Mr. Pearson may forget it at the present time. I think at the time we made our comparison Mr. Pearson was making gas almost entirely from oil.

Mr. Nettleton—We are drifting somewhat away from the paper. Speaking for myself, I want to say that the paper and its teachings have been a very great surprise to me. I had no idea that water gas had grown to the enormous extent stated in the paper and represented on the chart. I think that all of us must realize that Mr. Shelton has gone to an enormous outlay of labor in collecting all these statistics; and it seems to me that a hearty vote of thanks are due to him for preparing such a paper as this. Further than that, I know Mr. Shelton so well that I am confident he does not make the statement that he thinks he is within one per cent of being correct, or that the error is not more than one per cent., unless he is very sure that it is so. I am confident that this paper will go down as being an absolutely reliable paper of reference on the subject of water gas down to the present year. I move that a hearty vote of thanks be given to Mr. Shelton for his very able paper on water gas. I do not intend by this motion to cut off the discussion.

Mr. E. C. Brown—Mr. Nettleton has stated what I had intended to say, and so I will merely second his motion. [The motion prevailed.]

The President—We will next listen to the reading of our last paper, by Mr. Charles L. Rowland, entitled

GASHOLDERS: THEIR CARE AND OPERATION.

Somewhat more than a century ago, when gases first began to attract the attention of scientific men, the gasometer or holder was invented by the great French chemist, Lavoisier. Owing to this invention, the utility of gas for lighting purposes became practicable, for previous to this the only means for the storage of gases had been bladders. The most ancient holders were square or rectangular in form, and designed as a measurer of gas for experimental purposes only, hence the term gasometer. Gradually, however, as gas became a commercial article, and has finally proved itself the light of the Nineteenth Century, the gasometer developed into a reservoir for the mere storage of gas, and as now used, the simple name of gasholder is more appropriate.

These holders, in their early days, were made in one section only, and operated in wooden tanks. In 1814, the English government was strongly urged to restrict gas companies from constructing holders exceeding 6000 cubic feet capacity; since then, however, the dimensions of gasholders have increased at a marvelous rate, especially so during the last fifteen years; and nowhere are they built on so large or grand a scale as in the same country where the restriction was sought. The necessity for increased storage capacity at a low cost, brought out the idea of building holders of more than one section, by use of the hydraulic cup and seal. This method is commonly called the telescopic system, and has proved to be entirely successful, demonstrated as it is by the practical operation of the enormous three and four sectioned structures of the present day. Thus, we now find gasholders consisting of two types, viz.: the single lift, and telescopic; the latter type embracing all made in more than one section or lift, and to distinguish them are called, double, triple and quadruple lifts.

One of the most essential features in the operation of the holder, whether single lift or telescopic in character, is that it shall work smoothly up and down the guides with as little friction as possible, without getting out of level to any appreciable extent.

Stability of Holders:—Let us consider the holder as a vertical cylinder, and see why it should be unstable and liable to get more or less out of level; assuming the center of gravity to be the pivotal point. If the cylinder has no top, its center of gravity (assuming its sides to be of equal weight throughout), would be in the center of its length or height, and it would of course be in equilibrium. Now then we close the top end and in so doing add as much or more weight at the top than we have in the sides, the result being our cylinder is top-heavy and would overturn unless supported and held in position. For instance, a gasholder of ordinary construction, 100 feet diameter and ten feet height of section, would be quite out of proportion. The cylinder in this case being too short for its diameter, would be quite unstable. There would be about twice the weight in the roof that there is in the sides, and the center of gravity in consequence would be very high, being close under the center of crown. Such a vessel would prove extremely troublesome, the natural sequence being that it would be ever ready to invert upon slight provocation. The operation, therefore, of a holder depends largely on its proportions and structural character, a knowledge of which should be possessed by those who have the structure in charge, in order to know the cause of difficulties which may occur in its operation from time to time. It often happens that more pressure is required than the natural weight of the holder will give, and as avordupois is all that is needed to obtain the desired pressure, the first impulse is to load the roof. It may perhaps be the case that the holder is of shallow section which already is overloaded at the top, and if its weight is to be increased, it should be added at or as near the bottom of the section as possible. When the necessity of this added pressure is imperative, it is sometimes unwisely decided to obtain it in the easiest manner, and in consequence the operation is oftimes attended with disastrous results. I would, therefore, caution those in authority, to look well into the matter before deciding how increased pressure shall be obtained. To the want of proper precaution under the above conditions may be ascribed the many instances where gas companies have sustained serious damage to, and in many cases the total loss of a holder.

Hydraulic Seal.—In all telescopic holders the hydraulic seal must be cared for, the old style of construction being as shown by Figure 1. Although the cup rises from the tank filled with water, there is always with this form quite a loss of the seal; due to the fact that as soon as the gas pressure is exerted upon the inner portion of the cup, the water at A is depressed as many inches and fractions thereof as there is gas pressure, causing an equivalent amount of water to overflow at B the top of the section coupled, thus greatly diminishing the depth of the seal. The more modern and improved method in shown by Figure 2. And although as will be seen the only difference in construction consists in carrying the dip sheet some six inches or more above the top of the dip, nevertheless it is an important feature, as it forms a dam which

prevents the overflow and consequent loss; the water in the latter case being depressed equivalent to only one-half the pressure at A, and rising to the same extent at B and confined by the dam, thus reducing the percentage of loss of seal one-half. There is also an important difference in the operation which is much in favor of the latter style. When the water accumulates from steaming the cup in the former method, it overflows the dip, and in cold weather forms large masses of ice on the side of the section; while the latter style will, if the dam be sufficiently high, simply confine the water while it rises at both A and B, and until the cup overflows at A, inside of the holder as in Figure 3, at which time the efficiency of the cup is complete.

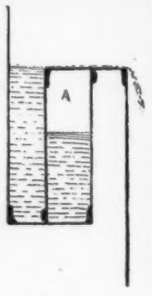


FIG. I.

FIG. II.

To prevent the water in the cup freezing, steam pipes should be carried up a portion of the height of the guide frame and connected with one or more jets in the cup, by means of flexible steam hose, the jets being located in the cup a few inches under the surface of the water, and supported in a horizontal position, so that the steam upon being turned on, will cause the water to circulate completely around the holder.

The cups are quite apt to be the receptacles for small stones and other missiles, especially when located near the public thoroughfare and exposed to the mischievous small boy of the neighborhood. They should occasionally be examined by feeling into them when they are near the surface of the water, and nearly high enough to engage with the next outer section.

FIG. III.

Care During Storms.—I have frequently been asked if it is not well to lower the holder during high winds. At first thought this would seem a rational thing to do, and for a single lift holder it would be quite proper. For telescopic holders, however, it is not wise; the better way being to raise them till the outer section is cupped, for coupling the two sections or three, as the case may be, doubles or trebles the length of the cylinder, thereby lowering the center of gravity, and otherwise causing greater stability. This increased stability, caused as it is by the additional length of the cylinder, more than compensates for the greater surface exposed to the force of wind; of course, this action can be taken only when two or more holders are in use. The same method should be employed in caring for a holder in times of heavy snow fall. During such storms the men should be employed in clearing the roof, the precaution being taken to equalize the working force, so that like parts of the roof will be cleared at the same time, keeping the holder as nearly as practicable in equilibrium, care being exercised to throw the snow well away, so that in falling it will not lodge in the cup or tank.

Tank.—The main feature in the care of the tank is that the water be kept up to the proper level, and that stones and other solid matter be prevented from falling in, which might in time be the cause of serious injury. The overflow should be frequently looked after, and kept free and clear.

Counterweighting.—Where the local conditions make it feasible, on general principles it is well to eliminate all counterweighting, but as specific statements under this head would open the door for considerable discussion, and as this feature may be considered as relating more properly to construction, I refrain from going into the matter in detail, but will simply state, where counterweights are in service, and it is desired to discontinue their use, it would be well to remove from the entire structure all the weights and counter gear.

Leaks.—All leaks however small should be promptly attended to as soon as detected; let them be repaired by a competent man, and furthermore one who will not as far as appearances are concerned, convert a new holder into an old one by injudiciously putting a patch here and another there, when all that is really needed is good judgment and the caulking tool.

Painting.—No precise rules can be laid down for determining how often a holder should be painted, as some climates are much more severe in their effects upon the painting than others, it being necessary in some localities to paint the holders every year, while in others a good coat in two or three years will suffice; but when it is done let it be thoroughly and well done, and no half way work about it. The mere coating the holder with the paint is the least part of the job when the work is done as it should be. Before painting, the sheets should be carefully scraped, removing all blisters and scales, leaving a good surface for the new coat to adhere to. If the painting is done without such a previous preparation, the objects ought, *i. e.*, the preservation of the structure, will not be attained. Undoubtedly the new coat of paint would greatly enhance its appearance, but oxidation and decay would be constantly doing their work under the cover of good looks.

Discussion.

Mr. Butterworth—I would like to ask Mr. Rowland how he would stop small leaks in the seam of a holder?

Mr. Rowland—The small, ordinary leaks that come in the seams of holders should be stopped with a caulking tool, as far as possible. It can generally be done, unless the iron is pretty well decayed. Almost any competent man can do a thing of that kind.

Mr. Glasgow—I agree with Mr. Rowland about raising the holder when you see a storm coming up, but my ideas of doing it are different from his. I want to raise my holder because I naturally want to have sufficient gas on hand ready for the increased consumption during the darkness caused by the storm. Of course it is very desirable to have the center of gravity below the geometrical center of the holder, but I do not see how to accomplish that by raising the holder. When you raise the holder you have the application of the wind higher up, and you have a larger surface exposed to the wind. I am unfortunate enough to operate a 500,000 holder which has to be watched every time it cups. This holder was constructed for the Kansas City Gas Light and Coke Company in 1876. When it was built there were blocks laid upon which the sections were built (in size 6 by 6, and about 18 inches long), and when the holders were filled those blocks were not extracted from the inside. Shortly after I went to Kansas City I was walking around the holder one day, and I found that it was very badly canted. One side was bulged in badly. This canting occurred a second time, and at that time the holder was so badly damaged as to make it impracticable for us to let it down; and we did a job of repairs upon it which seemed to me almost impossible when I first looked at it. The channel of the outer section was twisted so badly that, after we had it uncupped, it was tilted and the spring remained in it at an angle of 25 deg., horizontally. Inside of the cup the sheet was torn all to pieces, and the outside sheet had a crack in it six feet long, where the channel had bent out and kinked it in. I will not describe how we fixed it, as I suppose each of you know it better than I can state it; but we did fix it, and after that we had no further trouble. I do not think that holders occasion a great deal of trouble in their care and operation, provided they are properly constructed. In a holder that is being erected under my supervision, the foreman of the iron workers inquired how much out of plumb the walls were. He was told that they were a quarter of an inch out in the worst place. He expressed a great deal of surprise and satisfaction, and said that if they had been three inches out it would have made no difference, as the wall plates could have been easily sprung in to conform. He said that frequently they were five or six inches out, but that if they could get the girders on there was not much trouble in tilting the columns over, and it did not give any great trouble in construction. Of course when a man goes out like that, and expects to put up a large holder, and the superintendent permits the work to be done without supervision, it would be no wonder if a good deal of trouble was occasioned, and that the care and operation of the holder give a great deal of anxiety.

I once had a holder which I used to go around every day looking for leaks. It was such a shell that it had to be coated periodically with tar—which I considered a very bad thing to put on a holder—and water blisters had accummulated under the tar and rusted the holder and it was a mere shell in many places. I could see holes as large as pin heads, and I could run my finger at places into the shell. Then I would stop it up temporarily with something that I always carried in my hand when I went around the holder. I would put a patch on it. We found no difficulty in patching up such a leak anywhere if we could get at it—by a plan which may be common and universal, but which was original with me at the time. And that is simply having a saucer, and a retangular shaped nut or screw, probably three inches long, three-quarters wide, and a quarter of an inch thick. We would drop that inside of the hole, with a string tied around the top, then would fill up the saucer with a preparation of red litharge and glycerine, or any other good setting stuff, and draw the string through the centre of that and then put the screw in and clamp it up tight. In one day we put on a dozen of those on places where you could put your finger in. I am glad to say that that holder has since been renewed.

Mr. Rowland—I would say that in speaking of coupling the holder I have reference to the safety of the holder during a gale. The holder after coupling, forms a longer cylinder than before coupling. In the case referred to by Mr. Glasgow a new holder was undoubtedly needed.

Mr. Glasgow—I do not see how the center of gravity is lowered with regard to the geometrical center of the holder.

Mr. Rowland—But the center of gravity is lowered.

Mr. Glasgow—Relatively to the exposed part. It may come down from the top, but it travels up from the bottom.

Mr. Rowland—To illustrate: We will assume that the center of gravity is about *here*, in proportion to its height. Now, when we double the length, instead of the center of gravity being up here, it is away down there.

Mr. Glasgow—That is just what I say. It is lowered from the top but is has come up from the bottom.

Mr. Rowland—It is much nearer the bottom than it was before. I could illustrate to you by a diagram.

On motion of Mr. Nettleton, a vote of thanks was given to Mr. Rowland for his interesting paper.

THE QUESTION BOX.

(1) "*Can Electric Lights be Sold at a profit in Towns of* 8,000 *Inhabitants in Competition with Gas?*"

The President—If any of our members have had experience under such conditions we would like to hear from them.

Mr. Boardman—I am interested in a gas company which is operating an electric light station in a town of about that number of inhabitants; but I do not know as I am prepared to answer the question whether it will pay in competition with gas. We certainly are in competition with ourselves. The electric light is sold in competition with the gas which we sell ourselves; but as we have the regulation of the price of both, it is hardly fair to say that there is competition. In this particular case we do make money on the electric light. I will state that we charge $2 per thousand for our gas (with ten per cent. off for prompt payment, or $1.80 net); and while we are not using the incandescent light from an incandescent circuit—we are using what is called series lighting—we charge for 32-candle power lights $3 per month, and for 65-candle power lights $5 per month. The arc lights we sell at from $10 to $12.50.

Mr. Gribbel—Is that an all night circuit?

Mr. Boardman—The street lighting is an all night circuit, but the other is by the moon. For our 12 o'clock lights for stores weget $12.

The President—Perhaps Mr. Prichard can give us some information on this subject.

Mr. Prichard—I think it is entirely dependent upon local circumstances. In one company with which I am connected we have had about the same experience that Mr. Boardman speaks of, and have made it a commercial success.

(2) *Where Should a Gas Company's Ownership of Service Pipes Terminate—at the Street Curb, Lot Line, or the Meter?*

Mr. Taber—I would like to answer that question, and to answer it pretty liberally. I think a gas company ought to supply its own pipe to the meter; and I say so advisedly, because in these days of sharp competition, if you are going to undertake to so run a business as to make money on these minor details, you will lose your trade. I am perfectly satisfied of that in my own judgment, because I have seen it tried that way in the matter of coke. We used to sell our coke and the buyer would have to hire a horse and wagon to cart it, and then hire a man to put the coke in. Under these circumstances we never sold any coke worth speaking of. After we bought a horse and wagon of our own and employed a man to put the coke in we could sell what we pleased. I think that in these days, when competition is so great with electricity and water gas, that we had best be a little less cautious and a little more liberal in our expenditures. Of course, if the service pipe is a long one it would be weil that the parties should pay for it; but in most of our smaller towns the gas company can well afford to pay for the four or five feet of service pipe, rather than try to collect anything for it. In our locality we find that that plan works decidedly the best.

Mr. Boardman—There is another very strong reason in these days why a gas company should own its own services. Besides being able to put in such pipes as they choose, in order to properly protect themselves in case of leakage, they can also say when an opposition company sets up "We own our services, and if you are going for our patrons you must put in your own services." Then they will have to dig up the sidewalk again, which will prove very obnoxious to the householder, and he will very quickly give you a chance to talk with him after the opposition has seen him rather than have his sidewalk torn up. I would advise it by all means, whether it is a short service or a long one, that a gas company own its services and its meter connections.

Mr. Nettleton—Mr. President, have you any objections to stating what the custom is in Providence?

The President—We own our services, run all our services to the meters and set the meters without any charge to the consumer.

Mr. Butterworth—I have here a list of ten moderate sized cities of the country where they dispute that point as to the ownership of services. Only three out of the ten run their services free, even to the lot line; six of the others run to the curbstone; and one runs the services free only twenty feet from the main.

(3) "*Is it economy to use illuminating coal gas for fuel under boilers, with price of soft coal at $4.50 per ton? If it is, what kind of burners are generally used, and about what do same cost per set for furnace? If not, why not?*"

Mr. John Young—In reply to that question I would say that everything depends upon the price at which you can buy gas. If you can buy it for something like twelve cents a thousand feet it might be worth while to try the experiment. Coal at $4.50 per ton would be a little over 17 cents per bushel. A bushel of coal will develop a little over one million feet units, and it would take about 1,300 feet of illuminating gas to produce the same number of heat units. From that data the calculation can be made as to whether it would be more economical to use coal at $4.50, or coal gas. It depends entirely upon the price that must be paid for the gas.

(4) "*What proportion of the total is the present day consumption of gas in an average American city?*"

Mr. Butterworth—I do not know whether Columbus, Ohio, would be considered a representative American city or not, but I know what our day output is there, and what proportion of the total it is; and I can describe the city. It has 100,000 inhabitants; it has a fair quota of gas stoves; it is built on rising ground; it has no pall of smoke resting upon it; its streets are broad, and the buildings are not particularly high; and it has a large manufacturing interest for a State Capital. I am not booming the city for the World's Fair at all. The output there from six A. M. to six P. M. is about 22½ per cent. of the total.

The President—Have you any idea what number of gas stoves you have in use?

Mr. Butterworth--I have not.

(5.) "*Is it wise to make a special discount on gas used for cooking and heating?*"

The President—I think there are some companies making special rates for gas stoves, or for gas used for mechanical purposes.

Mr. Scriver—I may say a little something on that subject. I can say a good deal, but time would not permit. I think that our company (Montreal) was the pioneer company to make a different rate for gas stoves, gas engines and for manufacturing purposes, It is now about ten years since we commenced the introduction of gas stoves. We then made up our mind that it would be an advantage to our company to make a reduction. We were then selling gas at $1.70 for all illuminating purposes, and we made the price of gas for cooking stoves $1.20. The price to-day for illumination is $1.50, and we are selling gas for cooking and heating purposes for $1. We think it is a very great advantage to us. It might not be an advantage to every gas company in America, but we are pretty clearly of the opinion that for ourselves it is a very great advantage. At the present time we have about 3,000 gas stoves in use. Our consumption for gas stoves, and for heating and for manufacturing purposes, amounts to about one-fifth of our make. The revenue derived from the gas stoves for these purposes is about one-fifth of our whole revenue. We calculate that we sell for these purposes ninety million feet of gas per annum. That is a very large business of itself, and we would not like to be without it. The average price of gas with us would be about $1.25. We think we can manufacture gas and sell it at that price and make a handsome dividend or profit besides. We think that it pays—and I suppose that is the principal question. We think it pays very handsomely at these figures; in fact I know that it does. Other considerations might enter into this question, as, for instance, the consideration of philanthropy; but I do really think that we ought to be philanthropic. I think that we ought to be generous, and treat our customers in a liberal and generous way. That is a very great point to be gained. It is generally supposed that gas companies are very selfish, and since the introduction of the electric light, I believe that it is our policy, more than ever before, to be liberal and generous to our customers. We, therefore have made this reduction, and treat our customers in this generous manner. Of course you will easily understand that to manufacture the ninety millions of extra gas that we are making, over and above what we would manufacture without this business, causes us to employ an extra number of men. It also means to us the carbonization of about 9,000 tons of coal extra, and that means employment to a large number of men in various ways, and it means the support of a large number of families. I would not like to take up your time further in expanding this consideration. I do not know that it is of very great interest to you, but still I mention these things in order that we may fully understand that we should be generous and philanthropic also (applause).

Mr. Pearson—We have been selling gas at a reduced price for the purposes which have been alluded to, during a period of about eight years. I am satisfied that selling it at a reduced price has very greatly increased the consumption. Our selling price for gas, when we begin to sell it cheaper for heating purposes, etc., was $4.50; and we reduced the price for those purposes to $1. Our present selling price for illuminating purposes is $1.25, coming down to $1.10, and we have kept the other price at $1. I find that consumers are very ready to take gas at $1, but when, under certain circumstances, we talk of charging $1.25, because we did not think that the consumption was large enough to warrant such a low price, our consumers strenuously objected. During the past year the gas stove companies in Toronto have sent out at least a thousand gas stoves and heating apparatus, and I believe that they could not have sent out one-half that number had we not reduced the price. I think, moreover, that we can afford to sell gas for those purposes because it is very largely a summer consumption, and a day consumption, and by that means we utilize our plant more fully, and during a greater portion of the year than we otherwise would do.

Mr. Nettleton—I would like to ask Mr. Pearson for what purposes he sells gas at $1.

Mr. Pearson—For cooking, heating, power, and for mechanical purposes where they burn enough—such as for soldering irons, jewelry stores, and for anything except for illuminating. We have a separate meter and do not charge any rent for it. We lead pipes from the other meter to where the gas is to be used. They simply pay the expense of the piping from where the pipe enters the house to where the meter is. I might add that the amount of gas that we are sending out for those purposes is about thirty million feet, and we are getting paid for four hundred million feet for all purposes.

The President—Do you know how many gas stoves you now have in use?

Mr. Pearson—I have no memorandum of the number with me. We have a good many gas fires as well as gas stoves. I think altogether, of gas fires and gas stoves, we have about 1,500. And besides that we have a great deal of gas used for mechanical purposes which does not come under the low price, because they have not got separate connections. I am quite certain that we send out thirty million feet of gas for those purposes.

Mr. Scriver—The reason why our consumption is so large, and why we have so many stoves out, and why we pay such attention to this branch of our business, is that we manufacture our own gas stoves, and we sell them to our consumers at a very small profit. We fit them in their houses free of charge. We do not charge them

anything for attaching to the meter, nor do we charge for the pipes leading from the service to the gas stoves, but we do charge a small annual rental for the meter.

(6) "*Is the scheme of introducing air into gas for the purpose of revivifying the iron a success.*"

Mr. Butterworth—At Columbus, Ohio, we introduce a little air into our gas for the purpose of prolonging the life of oxide in the boxes, and we find it a great aid. We have a very poor local coal, which has probably almost as much sulphur in it as any coal in the market, and we find that the introduction of air is a great relief in using that coal. One-half of the coal is of that kind. The operation has not been conducted with a view of collecting any accurate data that would be of any great value from a scientific point of view, but only in a practical way. I do not know exactly what proportion of air we use. At first we tried to regulate and measure the air by passing it through an ordinary sixty-light meter, but like all other meters registering gas it got to going too slow and we abandoned it. Now we simply use it by drawing the air through a sealing of one-tenth of an inch of water. We watch it closely, and find that we keep our power up to 18 or 19 candles by using from four and a half to five per cent. of cannel coal.

Mr. Robert Young—Do I understand Mr. Butterworth to say that he has no means of ascertaining how much air he introduces into the gas?

Mr. Butterworth—I am not prepared to say.

Mr. Robert Young—Nor how much it diminishes the illuminating power?

Mr. Butterworth—Except by the fact that we keep it up to 18 or 19 candle power by using 4½ to five per cent. of cannel coal. I do not think that we introduce more than one per cent. of air.

(7) "*What progress has been made this year in the matter of regenerative furnaces?*"

The President—I think that Mr. Weber will answer that question.

Mr. O. B. Weber—I do not know what actual progress has been made except from the fact that we have introduced more this year than we did last year. As against 80 last year we have this year introduced 138, and they have been used as far North and West as Victoria, B. C., and as far South as Venezuela, S. A.

The President—This question is perhaps a little indefinite. The writer does not state whether he means progress in the kind of furnace used, or in the number that has been introduced. Perhaps he means both.

Mr. O. B. Weber—As to that I may say there has been an improvement in the construction of the furnace, in the way of making it more lasting; and we have also been able to reduce the formation of clinker. In fact, we are able to get along without any clinker at all. They have also been improved in the way of more readily controlling the heat. Beyond that we have made no improvement; but, of course, those are very essential, and have brought the furnace to the point of success.

(8) "*How should fire brick and tiles be laid—wet or dry?*"

The President—I think Mr. Weber can answer that question also.

Mr. O. B. Weber—I should answer it by saying that they should be laid neither wet nor dry, but dipped, so as to allow the mortar to adhere more easily and stronger. Unless fire brick is laid in that way there is a strong tendency for the mortar to scale off; and, therefore, we dip our brick.

Mr. Bredel—If the brick is largely silica it has to be laid wet; on the contrary, if the brick is largely aluminum, it has to be laid dry.

(9) "*What composition of gas will give the highest illuminating power when burned with a common fishtail burner passing 5 feet per hour, and convert all the carbon into* CO_2?"

Mr. Robert Young—I would answer by saying a gas containing the largest amount of hydrogen and the smallest per cent. of marsh gas. The percentage of hydrogen and carbon would be the same in both cases.

(10) "*What specific gravity of oil will yield the greatest amount of gas with the highest illuminating power?*"

Mr. Robert Young—I think the oil with the lightest specific gravity that you can find will give the highest illuminating power. I would like to hear some discussion upon that point, as it is a very important question in view of the large amount of water gas used.

The President—I think Mr. Rusby can give us some information.

Mr. Rusby—I hesitate to say anything on the subject, but my experience in water gas, with crude oil and heavy oil, have been very successful; and I have always been led to believe that the greatest amount of illuminating power could be obtained from oil of the highest specific gravity. I have heard of figures which rather led me to the opposite belief. But until I have had a greater amount of experience, or have heard some figures quite different from those which have been given me, I shall have to adhere to my present opinion.

Mr. McElroy—I would say that oil of the highest gravity is the better oil. I was using for a considerable length of time the lightest crude oil that could be got. It bears a premium now of 25 cents—that is when ordinary oil is $1 per bbl. it sells for $1.25. I find that naphtha at $3.75 is cheaper than oil at $1.25. I use naphtha of from 68 to 70 gravity.

(11) "*What chemical change takes place when a liquid hydrocarbon is exposed to a high temperature and made into a permanent illuminating gas?*"

Mr. Prichard—I think that the compound would be broken up by the deposition of carbon, and that there would be more hydrogen than carbon.

(12) "*What economy is there in using naphtha at 4¼ cents per gallon as an enricher, instead of good cannel coal at $7 per ton?*"

Mr. Lansden—It depends upon what process and apparatus you use, and how you handle your naphtha. In some apparatus it is very much cheaper. I guess it is cheaper to do it by simply putting a pipe into the retort—with cannel at $7.

VOTES OF THANKS.

The President—We have no further business on the table. Has any member any business to bring up?

Mr. Lansden—I wish to move a vote of thanks to our worthy Secretary who has so admirably arranged the papers and carried out everything pertaining to his duties. Although we have been deprived of his services a part of the time, I wish to move a hearty vote of thanks to him.

The President—It gives me pleasure to put that motion. There is hardly a member in the room who realizes the amount of work done by our Secretary, unless he has had occasion to fill a similar position. The work done by the President is mainly done here at the meeting, and amounts to nothing at all as compared with what is done by the Secretary. [The motion was unanimously carried.]

Mr. Ramsdell—I desire to make a motion which I am sure will meet with a hearty response, which is that a vote of thanks be extended to President Slater for the able and efficient manner in which he has presided over our meetings.

[The motion was put by Mr. Harbison, and carried unanimously by a rising vote.]

The President—Gentlemen, I thank you most sincerely for your kind expression. In the discharge of my duties I have been laboring under difficulties, and a few days ago it seemed to me that it would be impossible for me to attend this meeting as I was suffering from facial neuralgia, and am not yet entirely over it. A year ago when I was elected to this position I promised that I would serve you to the best of my ability, and I have endeavored to do so. If I have succeeded in any way I am satisfied. (Applause.)

Mr. Scriver—As thanks appear to be the order of the day, I would like to move a vote of thanks to our worthy friend Captain White, who, without a moment's notice, was called upon to attend to the duties of the Secretary during the latter's absence. He did his part I am sure efficiently, and to the entire satisfaction of all of us. [The motion was unanimously carried.]

Mr. Harbison—I have the pleasure of introducing Secretary Humphreys, who will respond to the vote of thanks which you gave him so unamimously a few minutes ago.

Secretary Humphreys—Gentlemen, I was not in the room when you passed your vote of thanks. I did not expect thanks at this session, for I have been able to do very little work during the last few days. I think that the vote of thanks belongs entirely to my friend Capt. White.

Mr. Scriver—He has had it.

Secretary Humphreys—I am very glad he has, for I am certainly very much indebted to him myself for having done what he has to make this meeting a success. I felt very badly yesterday at being unable to attend to my duties, but I would have felt very much worse had not Capt. White been here. Knowing that he was here, and knowing how well fitted he was to do the work I felt very much easier about it. I thank you very much for your kind consideration.

Mr. Harbison—Before we adjourn I move that a hearty vote of thanks be extended to Messrs. Bartlett, Hayward & Co., of Baltimore, the Consoliated Gas Light Company, as represented by its President and Mr. Hambleton, and to the Maryland Meter and Manufacturing Co., of the City of Baltimore, for the entertainments which they have provided for us to-night and to-morrow. [Unanimously adopted.]

Mr. Starr—One of our members who has never before failed to meet with us, and one of the pioneers of this Association, has been unable to attend this meeting because of sickness. I think it would be gratifying to him if we telegraph to him the compliments of the Association, and an expression of our regret at his absence. I refer to Mr. Samuel Prichitt, of Nashville, Tennessee. I move that it be done.

The President—I know that there will be no objection to that, and the Secretary will telegraph him.

Accordingly the Secretary sent the following message to Mr. Prichitt:

BALTIMORE, MD., Oct. 17, 1889.

SAMUEL PRICHITT, Nashville, Tenn.:

The American Gas Light Association assembled, at its seventeenth annual convention, extends to you its heartfelt sympathy in your illness, its regret at your absence from the meeting, and expresses the hope that soon you may be restored to perfect health.

C. J. R. HUMPHREYS, Sec'y.

To the above the following answer was received:

NASHVILLE, TENN., Oct. 18, 1889.

To C. J. R. HUMPHREYS, Sec'y, Carrollton Hotel, Baltimore:

Greetings to all. I feel highly honored by your complimentary and sympathetic greetings as expressed in your dispatch, and trust you will have a successful meeting, and have a specially good time to-day. I would like very much to be with you. SAMUEL PRICHITT.

Mr. Lansden—I would like also to make a motion that the the thanks of this Association be tendered to the press of the city of Baltimore. I do not think we have ever been better reported than we have been at this session, and it well be well for us to give a vote of thanks to the representatives of the press.

[Adopted.]

The Association then adjourned.

Steam Plant for Isolated Electric Light Plants.

[Read by Prof. Jno. W. Sweet, of Rochester, N. Y., at the October meeting of the Western New York Association of Architects.]

It is evident that the growth of the electric light business was never so healthy as at the present time, and, further, that its introduction in new business buildings is the rule rather than the exception, and that money can be saved by making proper provisions for the plant before the plans of the buildings are adopted rather than after they are completed.

The two most prominent difficulties we have to contend with are height in the basement for the boilers, and length in the room appropriated to the engine and the dynamos. So far as it is left for the architect to decide, where it is not possible to get height for boilers, the best way out of the difficulty is to use high-pressure small boilers, and more of them.

The same tactics may be adopted in the case of boilers as have overcome the difficulties in engines. The small high-speed engine renders a small space available, and so with small high-pressure boilers. The objection raised against them is the danger from explosion, but this is imaginary, for, other things being equal, the 36-inch boiler is just as safe at 120 pounds pressure as the 72-inch at 60 pounds; but other things are not equal; more care and better material is almost invariably used with the high than with the low-pressure generator. Another point: the high-pressure boiler is the more economical, for the reason that it takes nearly a thousand units of heat to get the steam to atmospheric pressure, after which it only takes about twice as many units to get the 120 pounds that it does the 60 pounds, out of which we can get twice the work.

The argument is advanced that should a boiler explode the damage would be much more serious with a high-pressure than with a low, but this, I imagine, is not true to any extent. The large boiler at 60 pounds and the small one at 120 pounds would either be bad enough; but it is not necessary to take that into consideration, for there never was an explosion that was not preventable, and with modern safety appliances and a careful engineer, explosions may be classed as a remote contingency.

In this latitude, where buildings have to be heated by using the exhaust steam for the purpose, the cost of running electric lights is not very great; or, if preferred, one may say the cost of heating is not very great. Some get the notion that because in cases where the system is not properly arranged and a pound or two of back pressure is put upon the engine, the use of the exhaust costs as much as it comes to. But when one considers that when steam is exhausted at atmospheric pressure it contains 960 units of heat, and at two or three pounds pressure not over 970, the two or three pounds of back pressure do not amount to much. When there remains this vast amount of heat in exhaust steam, it is the height of folly to throw it away, for with a properly arranged system even the two or three pounds of back pressure may be avoided.

In placing a plant in an old building, lack of chimney capacity is often met with, and this in planning new should be considered. A round chimney flue is also better than a square one, but not easy to deal with running through the upper stories; a hexagon or octagon is also better than a square, and it would seem that the excessively large chimney breasts could be made less objectionable if three sides of an octagon or hexagon than a square.

My impression is that 60-horse power should be about the limit in size of boilers used, and if more power is wanted, double or triple the number. Twelve feet in height is the lowest that will do for the common tubular sort, and fifteen feet is better.

It is best to start the foundations around the boiler room down for that height, rather than start level with the balance of the building and undermine afterwards; and it is best to make room for four square feet of chimney flue for one boiler, six square feet for two, and eight square feet for three. How the coal is to be got to, and the refuse away from the boiler; where the water is to come from, where the pumps and heater are to set, and where the exhaust steam is to go, when not wanted for heating, are points to be considered.

In the beginning of the electric lighting business (which is scarcely more than ten years ago) there were so many things that we did not know that poor lights were not always attributed to the proper cause. When the real cause was not known it was easy to fancy it due to the engine, and while only to a certain extent was this true, it led to the construction and introduction of the high-speed small engine, because it was easier to properly govern a high-speed engine, and later because it seemed desirable to put electric light plants in places too small to admit the large motors. When it was supposed that more perfectly governed engines were a necessity, they were produced, and probably what constitutes proper governing and how it can be accomplished is far better understood than ten years ago; so that there are now quite a number of engines built that meet the requirements in the main. Similarly, the dynamos, lamps and systems of wiring have been improved, and quite a number of companies are erecting plants that satisfy the demands of their customers.

A first-class large slow-speed engine is more economical in steam consumption than a small high-speed one of the same power, but that is not claiming that all slow speed engines are more economical than all high-speed ones, or that because an engine is more economical in steam consumption it is the most economical to use, for there comes in the question of first cost, the cost or value of the room it occupies, the cost of attendance, oil and repairs. Another point in electric lighting—the question of an engine always going when you expect it to, is of vital importance.

For nearly all isolated plants the small high speed engine is almost a necessity, on account of room, and in most cases the amount of power required is variable, for which reason a divided plant—that is, two or three boilers and two or three engines—is often more satisfactory than a large one.

Where two engines and two boilers will just supply the maximum demand, another boiler and engine practically duplicates the plant; with three there is always one in reserve, and with a divided plant, as the demand for lights falls off, one of the two engines may be shut down.

The engines and dynamo should be on the ground, for, except by the most expensive provisions can they be put on the upper floors and be satisfactory, and as the basement is the least valuable room and the best for the purpose, it is not good policy to cater to the notion that some have that they would like to make a show piece of their plant.

Making electric light is business, and it should be so considered. Many times it is necessary to put in a plant where the room is so short that the belt has to run back past the engine. This is bad, not only on account of the inconvenience and danger, but because it puts all the work on the upper half of the belt, allowing the lower half to sag away from the pulleys, reducing its driving power, and ends in its dragging on the floor and working badly.

For an isolated plant of from 250 to 800 incandescent lamps, a room from 25 to 35 feet in length should be set apart, if possible; and if for one engine and two dynamos, 12 or 18 feet in width will answer; if two engines, 16 to 20 feet, depending somewhat on the kind of engines and dynamos used.

Usually it is possible to get the advice of a competent boiler maker and engine builder when making the plans, whether their special product is used or not.

To what extent architects are consulted as to the selection of the various parts of a plant, I do not know, but presume to some extent; and if so consulted, it stands them in hand to be prepared to give satisfactory replies, or, at least, avoid so far as possible making mistakes.

In regard to boilers, there are many new sorts, but mostly the new kinds are so tall as to be inconvenient in basements, and none, so far as I know, have shown such marked superiority over the common tubular sort as to supersede them.

Tubular steel boilers of the best material, moderate in size and properly set, are reliable and satisfactory. Kitts', or some other reliable high and low water alarm, with a good safety valve, makes the boiler safe, if in the hands of a temperate, competent man. Either two pumps, or one pump and one injector, for feeding are advisable. A good heater is such an element of economy that it should be included. Every pipe connecting either steam or water should have a stop valve and union in it. If two or more boilers, there should be a safety valve to each. If steam pipes are long they should be one size larger than the size the engine calls for, and thoroughly jacketed.

Boilers and engines vary in price, the same as clothing. If the low price is insisted upon, the maker is going to put in cheap stock and do poor work.

The man who furnishes the poorest of all is the man who offers the largest bribe, for the bribe is not coming out of his pocket. He is either going to take it out of the goods or out of your client, and though he may try and ease his conscience by calling it a commission, it is a bribe all the same. As it is always the best goods that command the best prices, so it is safe to conclude that the price is a measure of quality.

In many places quiet running of the engine and dynamo is essential, and with noisy engines various devices, such as sand bed or layer of cork, have been used; but the engines should run without noise and the belts as nearly so as possible. There are other ways to drive without belts, that take less room and that ought to be less noisy. A cut gear with a leather (not rawhide) pinion, or the plan recently introduced of

putting the dynamo pulley within about one-eighth of an inch from the engine pulley and running a leather hoop between the two; I have known this device to work well in other places, and fancy it is feasible. But in laying out the room for a plant, it is best if possible to give the full length required for a belt, and this simply as a matter of economy.

As there are no restrictions, however severe, that will prevent an architect, if he has the genius, from making a good looking building; so too with mechanics, all things are possible. But when special boilers, engines, or dynamos have to be designed and constructed to fit odd places, the cost is increased immensely.

To better understand why it is desirable to have the plant in the basement, it is only necessary to consider one or two of the difficulties encountered in high speed. In the hundred-horse power engines the weight of the reciprocating parts varies from one-fourth to a half ton. This weight has to be started and stopped from four to five hundred times a minute, and yet while reaching a maximum velocity of from 900 to 1,000 feet a minute. Or to consider it in another way, we have from 500 to 1,000 pounds weight starting from rest, and in going 9 inches in the one-sixteenth part of a second, acquires a velocity of a thousand feet per minute, and is then in moving the next nine inches brought to rest; and to keep on doing this over and over for minutes, hours, days, and week after week silently, requires material, workmanship and a foundation.

As action and reaction are equal, to start and stop this weight must bring a strain on the framing and foundation were it not for counterbalancing, which is nothing more than putting an equal weight to the opposite side of the fly-wheel of the engine.

If this be correct it will fully neutralize the shaking tendency which would otherwise be destruction to the building; but the counterweight does not obviate all the difficulties, for when the tendency to shake the engine frame endwise is fully neutralized, the same force has an equal tendency to shake the engine frame up and down.

On the upper floor it is hard to resist either tendency, whereas on the ground one has the earth as an anvil, which seems best able of all things to stand it.

The danger of fire from the boilers can best be fortified against on the ground floor, and the trouble and noise from dynamos and belts are less troublesome.

It may be interesting, though of no value, to consider for a few moments the problem of engine regulation or governing. It is required of a machine capable of developing one or two hundred horse power that it shall make 150 or 200 revolutions per minute, and not go two turns slower if fifty per cent. more work be imposed upon it, and not over two turns faster in a minute if nine-tenths of the load be thrown off. This correction is accomplished by admitting more or less steam to the engine, which would seem simple enough; but remember, it is to be done by a machine already in motion, and by itself.

Were it possible to construct a valve steam-tight, that would move without friction and had no weight, the problem would be simple; but as no such valve exists the nearer one approaches it the easier the problem; and the more powerful the controlling mechanism and the freer it is from friction, the more nearly can perfection be approached.

The true test of governing is not the one usually employed—the general average of one minute with another—but at the maximum velocity of any one instant of time compared with the minimum at any other instant.

In conclusion, the isolated plant on the ground floor; small high pressure boilers with all the conveniences for operating, and all safety appliances that are reliable; engines that can be relied upon, or one in reserve; proper foundations, with plenty of working room when possible, and dynamos of standard merit in duplicate.

I have not referred to electric light plant for central stations, not because it may not be of interest and value, but because it is a subject better understood by the electrical engineers.

A CORRESPONDENT sends the following: "The Citizens Fuel Gas Company, for the manufacture of fuel gas by the Archer process in Terre Haute, has purchased about three acres of ground in the old canal bed, between First and Second and Eagle and Chestnut streets, for $3,500. This ground is peculiarly well adapted for the use to which it is to be put, being well below the surrounding levels and the general level of the city. The Company has received bids for piping and other material, and will award the contracts in a few days. The officers elected are: President, H. P. Townley; Vice-President, Anton Hulman; Secretary, J. R. Kendall; Treasurer, A. Z. Foster. It is said that the Company will be ready to supply gas by January 1st; but I am quite sure that this is an impossibility."

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

THE stockholders of the Concord (N. H.) Gas and Electric Light Company inspected formally, on the 26th of October, both divisions of their plant. The visit developed the fact that the Company is amply equipped to satisfy any demand that can be made upon it by its patrons.

THE Easthampton (Mass.) Gas Company's plant has been greatly improved by the installation of a handsomely finished specimen of the Roots type of exhauster.

SOME time ago we had occasion to speak of the defiant attitude assumed by the proprietors of Boston electric lighting companies in respect to their contributing towards the maintenance of a board of inspectors charged with the duty of certifying to the manner in which wires were laid on for the purpose of conveying electric lighting currents to shops, houses, etc. It seems, however, that the affair is in good shape for speedy and amicable settlement. As we understand, the compromise is something like this: The electric light companies offer to assume two-thirds of the cost of inspection, the Board of Fire Underwriters to contribute one-third of the cost. The Committee of the Board, to whom the matter was referred, was clothed with full power to act, and they have agreed to the compromise. Some details, of course, are to be arranged; notably, to determine the amount that will be required to carry on such inspections under the new conditions occasioned by the rapid increase in the number of city risks that are being wired for electric lighting, but no result of these unsettled details is likely to bring about a rejection of the compromise.

UP to and including October 21, 1889, the sales of engines by the Westinghouse Machine Company in that month are reported as follows:

Juniors.....	30 engines	.....	935-horse power.
Standards....	16 "	.....	645 "
Compounds..	30 "	.....	2,510 "
Total	76 "	.....	4,090 "

Among the purchasers in that period we note the names of the Allegheny County Light Company, the Albion (N. Y.) Electric Light Company, and the Missouri (St. Louis) Electric Light and Power Company.

AT a special election at Watertown, N. Y., the matter to be decided was whether the ruling electric light contract should be so amended as to provide for the burning of the lamps on each night and all night. The total vote was 750, of which 243 were in favor and 507 against the proposition. Under the present scheme the lamps are burned until midnight on 20 nights per month.

SOME time ago we noted the incorporation of a gas company for the town of Duquoin, Ills. Mr. Truesdale, of St. Louis, Mo., who has the contract for building the works, arrived on the ground something over a fortnight ago, and is now engaged in erecting the buildings. The contracts for pipe and machinery have been awarded.

GOVERNOR GORDON, of Georgia, has signed the amendments to the charters of the Atlanta and Gate City Gas Light Companies, under which the latter are empowered to furnish electric lighting.

THE West Chicago Water and Gas Pipe Line Company has been incorporated by Messrs. Andrew Crawford, Park E. Simmons and Robert R. Hertzog. It is capitalized in $1,000,000, and the proprietors propose to construct and operate gas and water works and to build a system of sewers in West Chicago.

IN the reorganization of the Brockton (Mass.) Gas Light Company it was thought that Mr. Bealis Sanford, who had acted as Treasurer for the Company for something like 29 years—in fact, almost since the incorporation of the concern—would continue at his desk. Mr. Sanford, however, has handed in his resignation, and Mr. Jas. W. Whitmarsh, of Boston, is to succeed him.

AT a meeting of the stockholders of the Citizens Gas Light Company, which supplies gas in the towns of Reading, South Reading, Stoneham, and Wakefield, Mass., it was decided to empower the Directors to take the necessary steps to engage the Company in the supply of electricity for light and power.

IN connection with our prior mention of the public lighting of Port Hope, Canada, the following (from the local *Evening Guide*) may not be without interest: "Now that the contract for street lighting is again

before the Council, we think it a fitting time to review the cost to the town of electric arc lighting as against the former outlay for gas lamps:

Taking the last year's outlay, when gas was fully in use, for 69 lamps, at $20 each	$1,380.00
Dividend paid to Town Treasurer by Gas Company, on account of Town gas stock, of $13,750, at 7 per cent.	962.50
Balance to be taxed for	$417.50
In 1889, 20 arc lights, at 23 cents cents each per night.	$1,679.00
Dividend paid by Gas Company to Town Treasurer, at 5 per cent	$687.50
To be taxed for	$991.50
Market value in 1886, during gas street lighting, of $13,750 of town gas stock, at 80 cents on dollar	$11,000.00
Same in 1889, under arc lighting, at 50 cents (last sale) on dollar	6,875.00
Loss by shrinkage	$4,125.00

Recapitulation.

Direct tax during three last years of gas street lighting, at $417.50	$1,252.50
Past three years arc lighting, at $991.50	2,974.50
	$1,722.00
Paid electric company for removal of plant	400.00
Depreciation of value of gas stock, as above	$4,125.00
Total extra outlay and loss during the past three years of arc street lighting	$6,247.00

Judging from the *Guide's* presentation of the matter, the authorities of Port Hope acted neither wisely nor well when they engaged in arc lighting. The other thing of interest in the above statement is the fact that an arc lamp displaced just 3 gas lamps, which leads to the suggestion that the Port Hope variety of arc lamp must be very weak indeed.

WE are informed by Mr. Geo. McMillan, of La Crosse, Wis., that at a recent meeting of the Council a proposition for public lighting, from the local Brush Company, was submitted. The offer was for 120 arcs (2,000-candle power, to be kept alight on the ordinary moon table) at the rate of $100 per lamp per annum, the contract to run for 6 years from January 1. Ald. Kelly did not like the moon table idea, but was decidedly in favor of every night and all-night lighting. Ald. Murray added that the latter procedure would involve an addition of 25 per cent. to the cost, and failed to see "that the practice would be worth the money, especially as the lighting company had signified its willingness to light on very dark nights, when notified by the proper officer." Murray evidently "had the Board with him;" for the proposition submitted by the Company was indorsed, and a resolution directing that a contract be entered into was passed.

PRESIDENT MAXWELL, of the Kearney Gas Company, has determined that the introduction of gas cooking and heating stoves in Lincoln, Nebraska, shall be attended with pronounced success.

SECRETARY and Superintendent Tracy, of the Alton (Ills.) Gas and Electric Light Company, thought he would be able to get along with two benches of 3's this winter, but the 30th of September had not been reached before he made up his mind that his theory was wrong. At least we judge so from the fact that he has placed an order with the Laclede Fire-Brick Company, of St. Louis, for an arch to hold six retorts. The Kerr Murray Company, of Fort Wayne, will furnish the iron work. When Tracy left Peru, Ind., to take charge at Alton, we predicted that he would make a success of it, and to show whether we were right or not in our estimate the following, from the local *Sentinel-Democrat*, is put in evidence: "Superintendent Tracy seems to be making every effort to give the city and private consumers the best quality of light, and his efforts appear to be successful. Our lights now are the best that we have had in several years."

SUPERINTENDENT ROGERS reports that the benches recently contracted for by the management of the Meridian (Miss.) Gas Light Company have been furnished and are in good working condition. The contractors faithfully carried out their agreement, and the plant is now capable of turning out 85,000 cubic feet of gas per diem. Mr. Rogers has had much to contend with since taking hold at Meridian, but his persistence conquered. He had one advantage, however, in that the present proprietors do not believe in saving a cent. to the ultimate loss of a dollar. In other words, they propose that their property shall be kept at a good state of efficiency.

IT WAS presumed that, according to the advices received by us a fortnight or so ago, the gas and electric lighting interests of Woonsocket, R. I., were now under one management. The following, however, goes to show that the deal has fallen through: "The consolidation of the electric plant of the Woonsocket Gas Company with that of the Woonsocket Electric Power and Machine Company, which has been under consideration, has fallen through, and the Gas Company will operate its own electric plant for the present. A few days ago, at a meeting of the Directors of the Gas Company, it was decided to furnish incandescent lights, the arc lights being all that they have supplied heretofore, from their present power. Additional power and dynamos will be put in at once. I understand that the failure of the negotiations was solely attributable to the extravagant demands made by the electricians. I, however, think that eventually the consolidation will be made, and it goes without saying—that is, among those conversant with the conditions at Woonsocket—that the longer the electricians hold out the worse it will be for themselves.—OBSERVER."

CONSIDERABLE attention has of late been directed to the probable life of the oil wells of the Baku district in Russia, and much seemingly authentic testimony has been advanced in support of the assertion that the output of oil at that point had reached the maximum. A foreign authority (no less reliable a one than *Engineering*), however, thus goes on record, on date of October 11th, in respect to the situation: "It is satisfactory to learn, on the authority of M. Gulishambaroff, that there is not the slightest ground for the rumor set in circulation by the acting consul at Batoum, that the Baku oil supply had begun to show signs of exhaustion. M. Gulishambaroff is the chief petroleum adviser to the Russian Government, and during the last ten days has been conducting an investigation into the oil industry, in conjunction with Mr. Marvin. Having only just arrived from Baku, after one of his regular official visits, he is in position to speak with authority on the state of affairs in that quarter, irrespective to that general knowledge of the Baku industry from the earliest time of its European development, which has resulted in the publication of so many books on the subject. So far from there having been a cave-in of the supply, there has really been a 'shut-down' of a large number of wells to check a wasteful over-production. Instead of 500 only 200 wells have been at work this autumn. Moreover, in order to put a stop to the waste of oil on the surface, the Russian Government has been lately discouraging the commencement of new wells outside the present limit. Administrative action of this sort has long been advocated by Marvin and other non-Russian writers, as well as by Russians themselves. It is no uncommon thing for a native of Baku to tap a supply of 20,000,000 gallons of oil and waste 19 millions out of it simply from want of foresight in providing a cap for the well, or by the omission to arrange for surface storage. Waste of this character has become such a scandal that to check it the authorities now seize a well that is not properly managed and empower the neighboring well owners to gag the supply at the culprit's cost. In view of the rapid increase in the demand for petroleum, it is a satisfaction to know that Baku is as prolific of oil as ever. The oil trade is assuming such gigantic proportions that for many a year there will probably be ample room for America, Russia and Burmah, as well as for the minor fields that will in time furnish a supply for the world's market. But in any case, petroleum ought not to be wasted as it has been at Baku, and it will be a good thing for Russia when the more careful and economical methods of America are adopted in the Caspian region."

IT is possible that the project, initiated in 1887, at Laconia, N. H., for the incorporation of Winnipesauke (N. H.) Gas and Electric Light Company will be revived. A meeting of the incorporators was called for Saturday, Oct. 26th, but we have not been advised as to the outcome of the same.

THE system of compressed oil gas supply recently introduced for the lighting of its cars by the Wagner Palace Car Company has proved so successful that the ordinary coaches of the New York Central and Hudson River Railroad are to be illuminated by the same means.

THE Newport (R. I.) *News* says: "The Committee on Street Lights is preparing to wrestle with that great question, the lighting of the city, and has called for proposals, to be submitted before November first, for a period of one or three years from the first of January next. The ad-

vertisement is quite general in its character and gives bidders a wide field for combinations. There are five headings for the street lighting: First, for 75 or more high-power arc lights; second, for 400 or more gas lamps, to be equipped with burners of 5 feet per hour capacity; third, the rate for gas for street lights; fourth, for 125 or more naphtha lamps: fifth, for 500 or more incandescent street lights. For lighting the public buildings proposals are asked for gas and incandescent electric lamps." The contracts about to expire were made on the basis of a life of 18 months.

It seems somewhat premature at this time to speak of the Savannah, Ga., convention of the American Gas Light Association, but as the local papers of that city are already discussing the affair, it might be well to reproduce here what the newsmen think about the proposed visit. The *News* (22d ult.) says: "The American Gas Light Association will hold its next annual convention in Savannah. Mr. David Douglas and others laid before the Association strong claims for Savannah, and especially impressed upon the members that the De Soto would then be open and equal to the task of accommodating the large number of delegates who go to make up the annual gathering. They had heard of Tybee and Bonaventure, and of the Harbor, and Mr. Douglas' earnest invitation, ably seconded by Mr. A. C. Humphreys, General Superintendent of the United Gas Improvement Company, won the fight for the Forest City, although it looked for a time as if Atlanta would get the prize. The Committee consists of A. C. Humphreys, Philadelphia: David Douglas, Savannah; A. E. Boardman, Macon; Thos. Turner, Charleston, S. C., and W. G. Abel, Atlanta. The American Gas Light Association is composed of about 400 members, the Association representing men of wealth who have many hundreds of millions invested. They will be the guests of the Mutual Gas Light Company, while in Savannah. The Association consists of representative men interested in the gas business. Hitherto the meetings have been confined to the very largest cities of the North and West, but the building of the De Soto Hotel made it possible to bring the convention to this city. Mr. Douglas said that not less than 300 gentlemen, many of them accompanied by ladies, will be here on the occasion of the gathering. 'Coming as they do from every important city in the United States and Canada,' said Mr. Douglas, 'and many of them gentlemen of great wealth and influence, and all of them men of ability, and representing large amounts of invested capital. it is seldom that such an opportunity will be presented to the people of Savannah to advertise their city as a delightful winter resort, as a place of vast commercial importance, and a beautiful residence city.' Mr. Douglas says it is the intention of the Mutual Gas Light Company to entertain the visitors royally. Drives to Bonaventure and Thunderbolt, excursions by rail to Tybee, and by sailboats and steamers on the river, will be on the programme, the whole to conclude with a magnificent banquet at the De Soto, to which prominent citizens will be invited."

The authorities of the borough of Shelton, Conn., have authorized the making of a contract under which the Derby Gas Light Company is to furnish a certain number of public arc lights in the first-named place.

Contractor Seeley, of Troy, N. Y., has been awarded the contract for constructing the plant under which the East Albany Gas Light Company will carry on the lighting of that place by means of arc lamps.

At the annual meeting of the Rockville (Conn.) Gas Company the officers chosen were: Directors, Geo. Maxwell, H. L. James, Geo. Talcott, S. G. Risley and J. N. Stickney; President, Geo. Maxwell; Secretary and Treasurer, J. N. Stickney. It was voted to increase the capital in the sum of $25,000, to pay for improvements now being made on the gas plant, as well as to meet the expenses incurred in the electric lighting installation. The new stock is to be issued at par to present shareholders, in the proportion of 100 per cent. of their holdings, the purchase money to be paid as called for by the Directors.

The Illinois Central Railroad has determined to light its passenger coaches with gas. Ordinary illuminating gas, compressed to 250 atmospheres, will be the agent. Each car carries three tanks, the total capacity of same being rated at 600 cubic feet.

About a fortnight ago the sales list of N. D. Winter, of Springfield, Mass., contained the announcement that on a named date 10 shares in the Springfield Gas Company would be sold at auction. Much interest was developed over the probable price that it would bring, but we think that the figure at which it was eventually knocked down, to Mr. L. B. Lewis, of Westfield, Mass., was far in advance of any that had been placed upon it by local estimators. It was started at 140, and bid off at 173. This is about 10 points over what was presumed to be the normal value, and is the highest figure at which a sale has been made within the past 12 years.

The gas works forming a part of the plant of the Lockwood Cotton Mills, Waterville, Me., were badly damaged by an explosion in the generating room, on the morning of October 24. Henry E. Washburne, Superintendent of the plant, was instantly killed. This plant was erected a year ago, and was intended for the generation of petroleum gas.

The Sage of Pawtucket must have had a right good time in Baltimore, even though it "did come high." We mean it must have been an expensive outing; for since his return home the Pawtucket *Evening Times* has told the following concerning him: "Mr. S. G. Stiness is wealthy, as he has the following bank bills and of the following dates: A $5 bill of the Berkshire (Mass.) Bank, dated 1807; $1 bill of the Randolph (Mass.) Bank, dated 1826; $1 bill of the Middletown (Ct.) Bank, dated 1818; $5 bill of the Hallowell (Me.) Bank, dated $1806; $1 bill of the Newburyport (Mass.) Bank, dated 1810; $1 bill of the Washington and Sandy Hill Bank, dated 1825. The bills were found in a book that had not been opened in 40 years." When a man goes rummaging through books that have not been opened in 40 years—well, the less said about it the better.

Some time ago we noted that the authorities of Toronto had caused the issuance of an injunction prohibiting the Consumers Gas Company from using the Jarvis street sewer for the relief of its works' drains. Manager Pearson and Assistant City Engineer Cunningham conferred together and decided that the best way to abate the trouble complained of would be by the construction of a second sewer through Parliament street, the same to be put down without manholes, and to be used exclusively by the Gas Company, the latter to pay all the expenses of construction. At this point City Solicitor Biggar stepped in and forbade the carrying out of the agreement, basing his edict on the ground "That if the city builds the sewer asked for by the Gas Company, although it be done at the expense of the Gas Company, the city will forever after be responsible for repairs and for keeping the sewer slushed out." This looks like very small practice, but it is of a piece with the general manner adopted by the local authorities towards one of the strongest, staunchest and most liberal corporations in Toronto.

The New Cumberland (West Va.) Light, Heat and Power Company has been incorporated by Messrs. Albert Haigh, R. E. Lindsay, G. W. Stewart, Jno. Porter and H. McMalen; capitalized in $50,000. The objects are stated to be: The supplying of light, heat and power by electricity or any other means. The Company's corporate life is placed at 50 years. This place is a post village of Hancock county, and is on the Ohio river at a point about three miles southwest of Fairview. Population, about 4,000.

The Chelsea (Mass.) Gas Light Company has asked the Board of Gas Commissioners to restrain the American Fuel Company from tearing up the streets of Chelsea for the purpose of burying its mains.

The Louisville (Ky.) authorities have determined to follow a mixed system (arcs and gas lamps) of public lighting, and the Louisville Gas Company will in all probability be awarded the contract. The Gas Company has decided to install an electric lighting plant.

The Market for Gas Securities.

The money manipulators have again managed to upset the market, and yesterday succeeded in getting the rate up to 12 per cent. We have no doubt, however, that their manipulations must eventually cease to be effective. Money should be abundant at about this time, and the law of supply and demand prevails in Wall street as well as elsewhere. With a normal state of the money market Consolidated would be much higher. To-day (Nov. 1) it is at 89½ to 90. During the week 100 shares were sold at auction at 89¾. Other city shares are fairly steady. In Brooklyn no change is reported. Jersey City gas is up to 192; 100 shares of this stock were sold at auction recently for 190. Baltimore Consolidated is weaker, at 42½ to 43½. One remarkable feature of the miscellaneous list on the Exchange is the steady tone maintained by Chicago Trusts, which are now held at 56. Boston gas (2d fives) are at 82½. We think that Boston common shares are a purchase.

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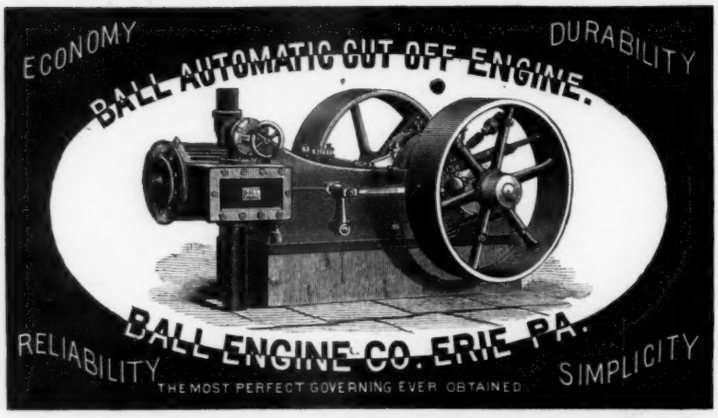

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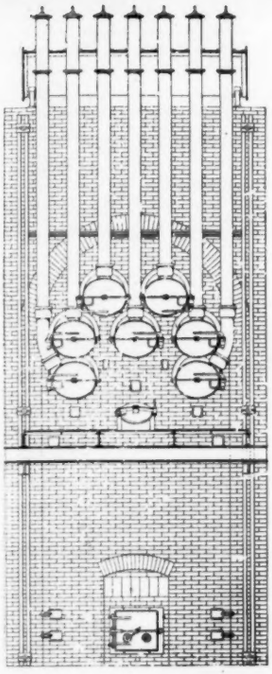

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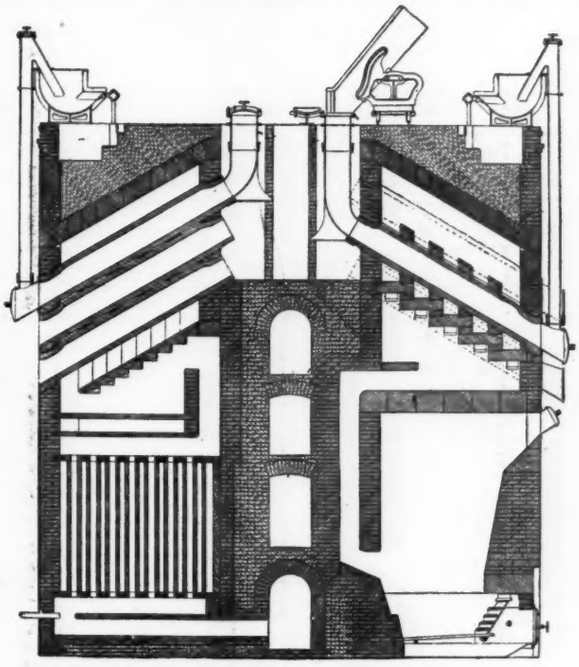

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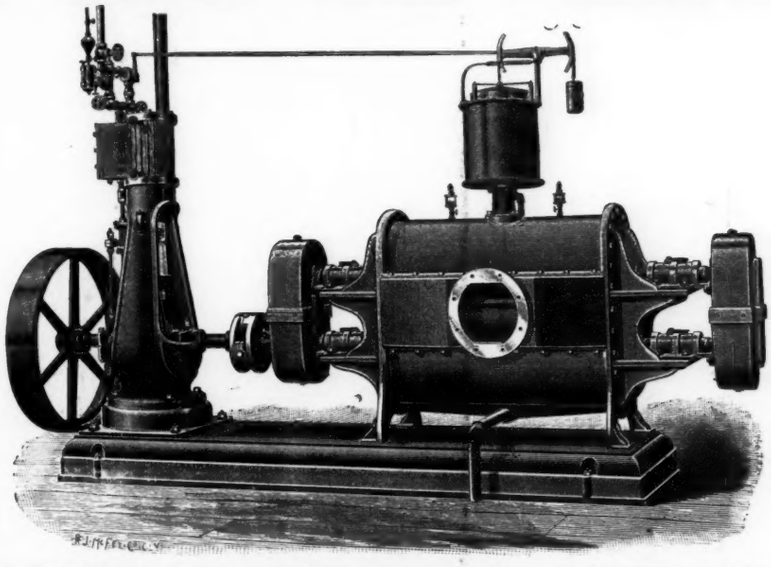

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Adelaide	600,000
Aldershot	200,000
Allegheny, U. S. A.	1,000,000
Ashton-under-Lyne	1,250,000
Amsterdam	1,500,000
"	1,500,000
Annaberg	200,000
Arcachon	100,000
Animal Charcoal Co	200,000
Altoona, U.S.A.	350,000
Buxton	250,000
Bradford	1,000,000
"	1,250,000
"	1,250,000
"	1,250,000
"	1,000,000
"	1,000,000
"	3,000,000
Bremen	150,000
Baltimore, U.S.A.	1,000,000
"	1,000,000
"	1,000,000
Balmain, N.S.W	125,000
Bishops Stortford	150,000
Blackpool	400,000
Brussels	1,250,000
"	1,250,000
"	750,000
"	1,250,000
Banbury	250,000
Birmingham	5,000,000
Birkenhead	2,500,000
Blackburn	1,500,000
Bochum	600,000
Burntisland	250,000
Boston, U.S.A.	2,000,000
Brisbane	1,500,000
"	300,000
Burton-on-Trent	1,500,000
Barcelona	350,000
Barking	100,000
Baerlien & Co	20,000
"	20,000
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Brookline, U.S.A.	500,000
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Beck & Co., St. Louis	100,000
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Bexhill	125,000
Brooklyn, U.S.A.	1,000,000
"	1,000,000
" **Nassau**	1,000,000
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Croydon	1,500,000
Copenhagen	200,000
Clevedon	200,000
Columbus, U.S.A.	500,000
Cincinnati, "	1,500,000
" "	1,500,000
Chicago "	3,000,000
" "	1,000,000
" "	1,000,000
Chemnitz	1,000,000
Crewe	1,250,000
Colonial Gas Works Co	100,000
Cadiz	300,000
Charlottenburg	600,000
Dudley	750,000
Driffield	100,000
Dukenfield	500,000
Dover	750,000
"	1,000,000
Deal	200,000
Derby	1,500,000

	Capacity. Cubic feet per day.
Dublin	3,000,000
Dowlais	100,000
Douai	500,000
Denton	500,000
Derby, U.S.A.	350,000
Denver, "	500,000
" "	1,000,000
Dusselldorf	750,000
"	500,000
Dumfries	250,000
Dunedin, N.Z.	400,000
Darlington	1,250,000
Detroit, U.S.A.	750,000
Edinburgh	1,500,000
"	2,000,000
Enfield	300,000
Essen	300,000
Elbing	150,000
Falmouth	150,000
Frankfort	300,000
Farnworth	400,000
Fenton	400,000
Friedenshutte	500,000
Furth	400,000
Freiburg	200,000
Goole	250,000
Glossop	300,000
Guildford	300,000
Gloucester	1,250,000
Gera	300,000
Grafton, N.S.W	100,000
Grieg	300,000
Georgetown, U.S.A.	250,000
Gluckauf	200,000
Heywood	600,000
Holywood	125,000
Huy	70,000
Harrow	250,000
Harrogate	250,000
Halstead	150,000
Heilbronn	200,000
Havana, Cuba	750,000
Hastings	1,500,000
Huddersfield	300,000
"	750,000
"	1,500,000
Hof	200,000
Hampton Wick	500,000
Heckmondwicke	500,000
Haverfordwest	100,000
Halifax, N.S.	350,000
Hamm	200,000
Halle	400,000
Heidelberg	300,000
Hartford, U.S.A.	1,000,000
Ilkeston	300,000
Inverness	250,000
Ilkley	200,000
Ilford	100,000
Kingston-on-Hull	400,000
Kidderminster	750,000
Kidsgrove	100,000
Konigberg	1,000,000
King's Lynn	300,000

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The Gaslight and Coke Co.:	
Beckton	1,250,000
"	1,250,000
"	1,250,000
"	1,250,000
"	1,250,000
"	1,250,000
"	2,500,000
"	2,500,000
Silvertown	1,000,000
Bromley	2,000,000
"	1,500,000
"	1,500,000
"	1,500,000
"	2,000,000
"	1,500,000

LONDON—*Continued.*	Capacity. Cubic feet per day.
Shoreditch	2,500,000
Pancras	1,500,000
"	1,500,000
Pimlico	2,000,000
Nine Elms	3,000,000
"	3,000,000
South Metropolitan Co:—	
Greenwich	3,000,000
Woolwich	400,000
Vauxhall	3,000,000
"	3,000,000
Lea Bridge	300,000
West Ham	1,500,000
Leeds	2,000,000
"	3,000,000
"	3,000,000
"	3,000,000
"	2,000,000
Leominster	150,000
Leiden	500,000
"	600,000
Liverpool	2,000,000
"	2,000,000
"	2,000,000
"	2,000,000
"	2,000,000
"	3,000,000
Lincoln	1,000,000
"	600,000
Lowell, U. S. A.	1,000,000
Louisville "	1,500,000
Long Eaton	500,000
Lilie	900,000
"	450,000
"	750,000
"	250,000
"	250,000
Luckenwalde	330,000
Liegwitz	300,000
Lincoln, U. S. A.	250,000
Lawrence "	500,000
Lynn "	300,000
Lyons	1,500,000
Maidstone	1,000,000
Marseilles	1,500,000
"	1,500,000
Mons	500,000
Malines	250,000
Melbourne	1,500,000
"	1,500,000
"	1,500,000
"	1,500,000
"	1,500,000
Manchester	2,500,000
Middleton	400,000
Manley, N. S. W.	100,000
Minneapolis, U. S. A.	750,000
Magdeburg	300,000
Memphis, U. S. A	750,000
Nottingham	1,250,000
"	2,500,000
"	2,500,000
"	2,000,000
"	1,500,000
"	2,000,000
Newport, U.S.A.	430,000
Newmarket	150,000
Newark, U.S.A.	680,000
Northfleet	200,000
New York, U.S.A.	2,000,000
Nice	600,000
Newcastle, N. S. W.	200,000
Numea, "	100,000
Namur	250,000
Newark	350,000
Oldbury	500,000
Otley	200,000
Oswestry	250,000

	Capacity. Cubic feet per day.
Ober Schlesian	1,500,000
Otto & Co.'s Coke Works	1,500,000
Plymouth	2,000,000
Parramatta, N. S. W.	100,000
Prescott	150,000
Providence, U.S.A.	750,000
"	750,000
Plauen	300,000
"	300,000
Portsmouth	2,500,000
"	2,500,000
Pittsburgh, U.S.A.	1,500,000
Portland, "	560,000
Pawtucket, "	500,000
Quebec	250,000
Radcliffe	750,000
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"	1,750,000
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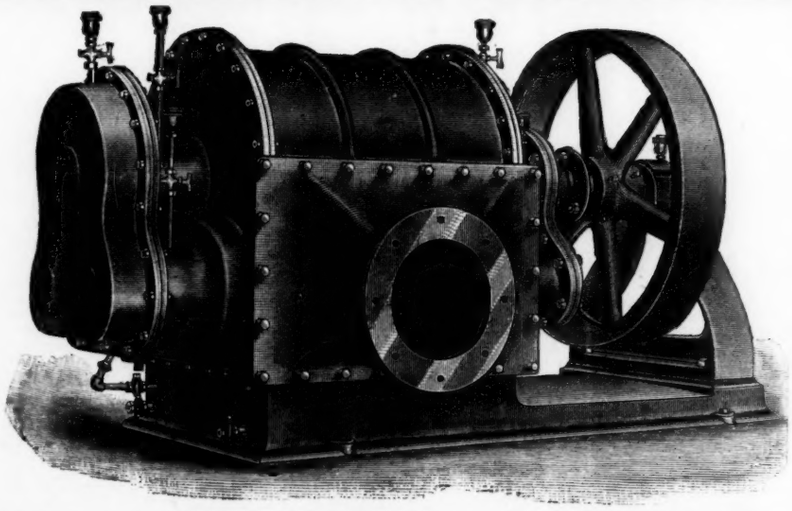

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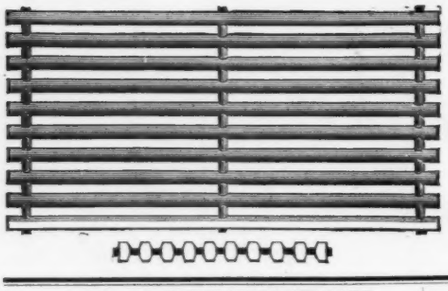

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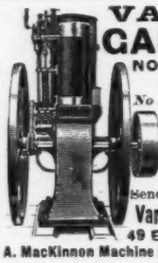

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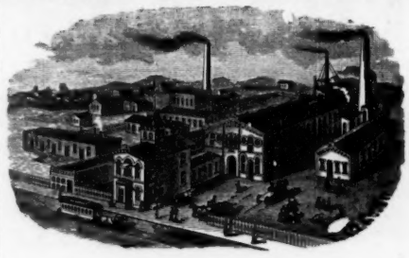

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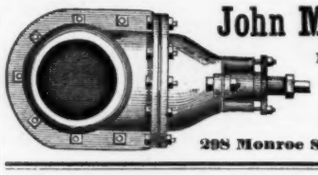

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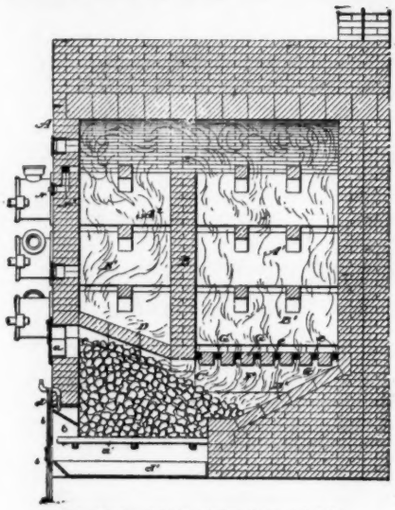

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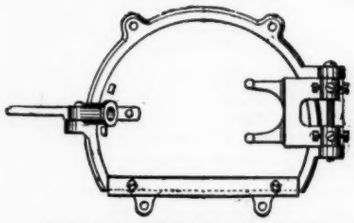

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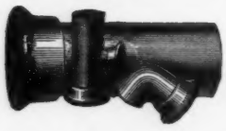

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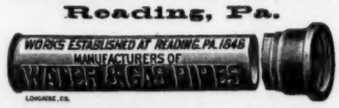

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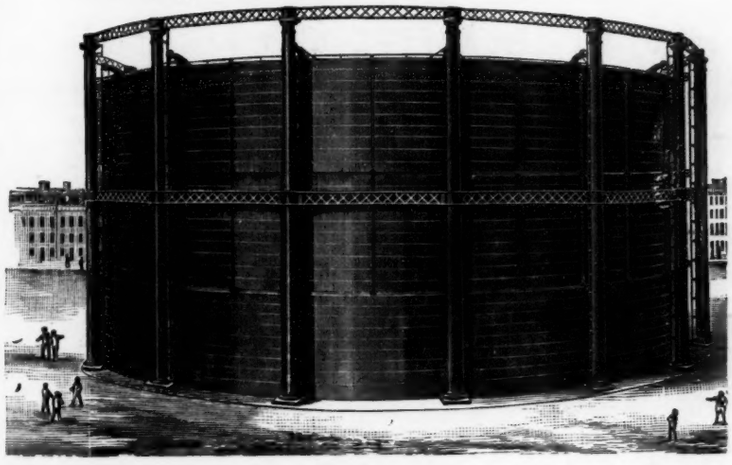

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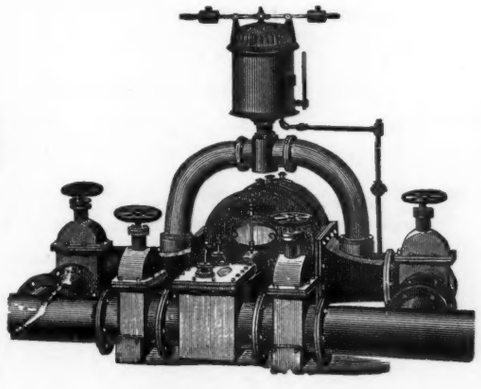

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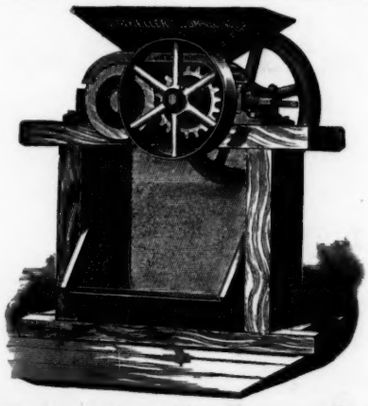

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Gas into Electricity

BY THE

OTTO GAS ENGINES.

Gas Companies are given by the Otto Gas Engine superior means for Production of Power and Electric Light.

In Theory the Otto Gas Engine realizes 18 per cent. actual work out of number of heat units in fuel consumed, while the ordinary steam plants reach but 12 per cent. **In Practice** a comparison of cost in dollars and cents between gas and steam power stands as follows (the figures below being taken from actual experience):

50-H.P. STEAM ENGINE AND BOILER, Running a Plant of Fifty 2000-C.P. Arc Lamps 12 Hours.	
4,500 lbs. Indiana nut and slack, at $1.30 per ton	$2 93
Engineer, one night, at $50 per month	1 67
Trimmer, one day, at $40 per month	1 33
Superintendent or Electrician, one day, at $50 per month	1 66
Waste, etc., one day, at $20 per year	05
Water rent, one day, at $40 per year	11
Wheeling coal and removing ashes, at $4 per week	58
100 pairs carbons, at $18.50 per 1000	1 85
One pint cylinder oil, at 60 cents per gallon	07
One quart engine and dynamo oil, at 50 cents per gallon	13
Total	$10 38

50-H.P. OTTO GAS ENGINE, Running a Plant of Fifty 2000-C.P. Arc Lamps 12 Hours.	
9,200 cu. ft. gas, at 42 cts. per M. (for cost of gas see items below)	$3 86
Engineer not needed; engine is in care of Electrician or Supt.	....
Trimmer, one day, at $40 per month	1 33
Superintendent or electrician, one day, at $50 per month	1 66
Waste, etc., one day, at $20 per year	05
Water rent dispensed with (cooling water used over and over)	....
Handling of coal included in cost of gas	....
100 pairs carbons, at $18.50 per 1,000	1 85
One pint cylinder oil, at 60 cents per gallon	07
One quart engine and dynamo oil, at 50 cents per gallon	13
Total	$8 95

Expenses of depreciation, repairs, and interest omitted, being considered the same in both cases—though depreciation and repairs are much higher with steam on account of boiler and its appurtenances. Cost of gas in the holder we estimate for most of the Middle and Western States as follows: Coal, 30 cts.; labor, 20 cts.; purification, 2 cts.; total, 52 cts. Less coke, 7 cts., and tar, 3 cts.; leaving net cost of gas 42 cts. The items of Superintendence and repairs, being paid for by the gas sold to consumers, need not be charged on extra output for gas engine consumption. Where the cost of gas is higher than here figured, coal for steam use will be found proportionally higher, and final figures of comparison show same amount of saving.

Excess in Cost of Steam over Gas Power is thus $1.43, or nearly 16 per cent.

Coal for getting up steam and banking fires is not included in above figures, and should be added, thus increasing rate of economy of gas power beyond that shown by our figures.

Where Gas Companies adopt Gas Power for Electric Plants, Water Works, Sewerage, etc., they not only choose **the most economical power for their use,** but secure to themselves the **numerous advantages of increased production,** without increase of expense, and benefit thereby their entire manufacture. They induce consumers, by their example, to abandon Steam for Gas Power, and, by establishing special rates, make

Gas Power the Leading Power of To-Day,

AND SOLVE AT ONCE THE QUESTION OF FUEL GAS.

"Otto Gas Engine Works,"

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